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Rev. 07/10/02

1607704

Five-Year Review Report

Second Five Year Review Report
for
Forest Waste Disposal Site
Otisville
Genesee County, Michigan

September 2002

Prepared By:

United States Environmental Protection Agency
Region 5
Chicago, IL

Approved by:

Wm. E. Muno

William E. Muno, Director
Superfund Division, Region 5
United States Environmental Protection Agency

9/30/02
Date

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Executive Summary

The remedy is protective in the short-term because there is no evidence that there is current exposure. In order for the remedy to remain protective in the long term, the following actions need to be implemented:

- Completion of the on-going north plume investigation to delineate and characterize the north plume;
- Evaluation alternatives and implementation of remediation of the north plume;
- until the plume is delineated or controlled, continue annual sampling of residential wells near the north plume area, and more frequent sampling of any nearby residential well that is screened in the shallow sand or deep sand and gravel aquifers;
- Evaluate the need to monitor for PBBs in ground-water, and add PBBs to the monitoring program if necessary;
- Either update the ground-water action levels in the SOW to be protective for exposure to multiple contaminants and non-carcinogens, or impose usage restrictions on the shallow sand and deep sand and gravel aquifers north of the Site, and on the shallow sand aquifer east of the Site;
- Evaluate the need to conduct air sampling to characterize landfill gas emissions, and implement the air sampling if necessary; and
- Evaluate the need to conduct soil gas monitoring, and implement the soil gas monitoring if necessary to assure that landfill gas is not migrating into off-Site structures.

EPA is taking the steps outlined in Section VII, Recommended Actions, to make the remedy protective.

Five-Year Review Summary Form

SITE IDENTIFICATION

Site name *(from WasteLAN)*: **Forest Waste Disposal**

EPA ID *(from WasteLAN)*:

Region: 5 | **State: MI** | **City/County: Otisville / Genesee**

SITE STATUS

NPL status: X Final ☐ Deleted ☐ Other (specify) _____

Remediation status (choose all that apply): ☐ Under Construction X Operating ☐ Complete

Multiple OUs?* X YES ☐NO | **Construction completion date: 6 / 30 / 1997**

Has site been put into reuse? ☐ YES X NO (only very limited usage)

REVIEW STATUS

Lead agency: X EPA ☐ State ☐ Tribe ☐ Other Federal Agency _____

Author name: RRS#6, Superfund Division, Region 5, U.S. EPA

Author title: | **Author affiliation: U.S. EPA**

Review period: 8 / 20 / 2001 to 09 / 30 / 2002

Date(s) of site inspection: 08 / 20 / 2001;

Type of review: X Post-SARA ☐ Pre-SARA ☐ NPL-Removal only ☐ Non-NPL Remedial Action Site ☐ NPL State/Tribe-lead ☐ Regional Discretion

Review number: ☐ 1 (first) X 2 (second) ☐ 3 (third) ☐ Other (specify) _____

Triggering action:
☐ Actual RA Onsite Construction at OU #____ ☐ Actual RA Start at OU#____
☐ Construction Completion X Previous Five-Year Review Report
☐ Other (specify) _____

Triggering action date *(from WasteLAN)*: **6 / 30 / 1997**

Due date *(five years after triggering action date)*: **6 / 30 / 2002**

* ["OU" refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

Issues:

1. The 1988 ROD provides for prevention of use of the shallow aquifer for drinking water not only on-Site, but also in adjacent areas. Deed restrictions and ownership of the Site and 80 acre parcel north of the Site by the Township, along with oversight by EPA, MDEQ and the FWCC should reliably restrict usage of the shallow aquifer on-Site and on the 80 acre property. However, there is no formal control over ground-water usage on adjacent properties. This is primarily a concern north and west of the 80 acres where VOCs exceeding action levels have been detected and a considerable number of residences have been constructed since the time of the RI and further development is likely. Development east of the Site appears to be less likely, but still could occur.

2. Even though the east plume has been monitored in compliance with the Consent Decree SOW, PBBs were never analyzed apparently because PBBs were not considered to be a threat to ground-water. This assumption should be revisited because the landfill is known to be a major source of PBBs. The east plume monitoring has been reduced substantially since 1999, but review of the most recent monitoring data indicates that it may be premature to substantially reduce monitoring of the east plume.

3. To date, the north plume contamination is still not adequately characterized to evaluation remedial alternatives. During this continuing investigation, nearby residential wells must continue to be sampled periodically to assure that their drinking water is safe. The FWCC has stated that they will submit an evaluation of alternatives to address the north plume within 30 days after receipt of the validated data from the most recent phase of investigation. Metals, SVOCs, pesticide/PCBs and PBBs have not yet been adequately characterized in the north plume, but this will be done after the extent of the north plume is delineated based on the VOC data.

4. The drinking water protection action levels are protective if the shallow sand and deep sand and gravel aquifers are not developed to the north or east of the Site and of the 80 acres north of the site. Presently there are no formal restrictions on such usage. If such usage occurs, compliance with the drinking water protection ground-water action levels from the SOW may not provide sufficient protection to off-Site ground-water users.

5. Ambient air emissions, and soil gas migration are very unlikely to be a problem at this Site, but this has not been verified by field measurements.

Recommendations and Follow-up Actions:

1. As is planned, the ongoing north plume investigation needs to be completed to delineate and characterize the north plume. This investigation is being conducted by the FWCC with oversight by EPA and MDEQ. MDEQ is also conducting an investigation to detect contamination venting to the lake.
2. As is planned, options for remediation of the north plume need to be evaluated, and implemented. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA. MDEQ will also provide oversight
3. As is planned, annual sampling of residential wells near the north plume area should be continued. More frequent sampling should be implemented for any nearby residential well that is screened in the shallow sand or deep sand and gravel aquifers. This is expected to be conducted by the FWCC with oversight by EPA and MDEQ.
4. As is planned, a new long-term monitoring plan, including monitoring the north plume, the east plume and near the landfill, should be developed after delineation of the north plume is completed. Considerable attention to the east plume is still needed. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA. MDEQ will also provide oversight. Including in the monitoring and analysis of total metals instead of filtered metals should be considered.
5. The existing maintenance program for the landfill cap and fence should be continued. Periodic inspection and maintenance of the fence around the Site should be added to this effort. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA. MDEQ will also provide oversight.
6. Either the ground-water action levels in the SOW should be updated to be protective for exposure to multiple carcinogenic contaminants and to keep exposure rates for non-carcinogens below their reference doses, or usage restrictions should be imposed on the shallow sand and deep sand and gravel aquifers north of the Site, and on use of the shallow sand aquifer east of the Site. EPA will attempt to gain cooperation from the FWCC and/or the State and local government to address these recommendations.
7. The need to conduct air sampling to characterize landfill gas emissions should be evaluated, and the air sampling conducted if necessary as required in the SOW. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA. MDEQ will also provide oversight.
8. The need to conduct soil gas monitoring should be evaluated, and the soil gas monitoring conducted if necessary. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA. MDEQ will also provide oversight.

Protectiveness Statement(s):

The remedy is protective in the short-term because there is no evidence that there is current exposure. In order for the remedy to remain protective in the long term, the following actions need to be implemented:

- completion of the ongoing north plume investigation to delineate and characterize the north plume;
- evaluation alternatives and implementation of remediation of the north plume;
- until the plume is delineated or controlled, continue annual sampling of residential wells near the north plume area, and more frequent sampling of any nearby residential well that is screened in the shallow sand or deep sand and gravel aquifers;
- evaluate the need to monitor for PBBs in ground-water, and add PBBs to the monitoring program if necessary;
- either update the ground-water action levels in the SOW to be protective for exposure to multiple contaminants and non-carcinogens, or impose usage restrictions on the shallow sand and deep sand and gravel aquifers north of the Site, and on the shallow sand aquifer east of the Site;
- evaluate the need to conduct air sampling to characterize landfill gas emissions, and implement the air sampling if necessary; and
- evaluate the need to conduct soil gas monitoring, and implement the soil gas monitoring if necessary to assure that landfill gas is not migrating into off-Site structures.

I. Introduction

This report presents the results of the second Five-Year Review for the Forest Waste Disposal site (Site) located in Genesee County, Michigan. This review was performed by the United States Environmental Protection Agency (EPA). The following parties also provided input into the review:

- the Michigan Department of Environmental Quality (MDEQ) formerly the Michigan Department of Natural Resources (MDNR); and
- the Forest Waste Coordinating Committee (FWCC).[1]

The Purpose of the Review

The purpose of this review is to evaluate implementation and performance of the remedial actions in order to determine whether or not the remedy is or will be protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues found during the review, if any, and recommendations to address them.

Authority For Conducting the Five-Year Review

The Agency is preparing this five-year review pursuant to CERCLA §121 and the National Contingency Plan (NCP). CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The agency interpreted this requirement further in the National Contingency Plan (NCP); 40 CFR §300.430(f)(4)(ii) states:

If a remedial action is selected that results in hazardous substances, pollutants, or

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[1]This is a group of private potentially responsible parties who are performing the remedial actions at the Site in accordance with the requirements of a Consent Decree between the parties and EPA.

contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

Who Conducted the Five-Year Review

The United States Environmental Protection Agency (EPA) Region 5 has conducted a five-year review of the remedial actions implemented at the Forest Waste Disposal site in Otisville, Michigan. The first Five-Year Review was completed on March 28, 1997. This Five-Year Review was initiated on December 14, 2001. The actual date of completion is the date of signature shown on the title page. The remedial action that EPA selected for the VWF will result in hazardous substances remaining above concentrations that would allow unlimited use and unrestricted exposure at the end of the remedial action. Therefore, a Five-Year Review is required by statute.[2]

This Five-Year Review was drafted by Richard Boice, who has been EPA's remedial project manager (RPM) for this Site since December 1998. Other EPA staff having input into this review include Luanne Vanderpool, Hydrogeologist, and David Brauner, Ecologist. MDEQ staff provided limited input into this review include Sally Beebe, MDEQ's site manager, and William Bolio, Hydrogeologist. In addition, the FWCC, and technical specialists from Conestoga-Rovers & Associates (CRA), who is a technical consultant working for the FWCC, have had input into this review before it was finalized. A risk assessment specialist for human health impacts was not involved because only a screening-level risk assessment was needed.

This report will be placed in the Forest Waste Disposal Site (Site) Administrative Record file located at EPA's office at 77 W. Jackson Boulevard, Chicago, Illinois, and in the local document repository, which is located at Forest Township Library, 130 East Main Street, Otisville, Michigan 48463.

II. Site Chronology

1972-1973: Permits were issued by the MDNR to the Site property owners to receive general refuse and limited types of industrial and liquid waste.

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[2] Section 121(c) of the Comprehensive Environmental Response Compensation and Liability Act, 42 U.S.C. § 9621 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and Section 300.430(f)(4)(ii) of the National Contingency Plan, requires periodic review (at least once every five years) for sites where hazardous substances, pollutants or contaminants will remain above levels that would allow unlimited use and unrestricted exposure after completion of the remedial action

1973-1978: Wastes were disposed at the Site in a landfill and nine waste lagoons. During this period of time the MDNR and Genesse County Health Department (GCHD) inspected the Site numerous times, including witnessing the burial of PBB contaminated cattle feed, and there was numerous correspondence regarding disposal approvals, and complaints. MDNR did not renew the Site permit in 1978.

1978-1982: In 1978 MDNR installed and sampled seven monitoring wells, and the GCHD collected samples from 19 residential wells, and 4 surface waters for PBB analysis. MDNR sampled lagoons in 1978 and 1979, and repeated monitoring well sampling three times in 1979 and 1982.

1983-1988: In 1983 the Site was added to the National Priorities List. EPA conducted the remedial investigation/feasibility study (RI/FS).

1984: EPA constructed a fence around the Site, in accordance with an initial remedial measure record of decision (ROD) issued that same year.

1986: EPA issued a ROD providing for removal and off-Site treatment and disposal of approximately 110,000 gallons of contaminated liquids, and 4,000 cubic yards of contaminated lagoon sediment, sludge and soil.

1987: MDNR assumed ownership of the Site property.

1988: EPA issued a Unilateral Administrative Order (UAO) to potentially responsible parties (PRPs) ordering implementation of the 1986 ROD. EPA issued a ROD for final remedial actions including:

- removal and off-Site treatment of drums containing wastes and associated saturated contaminated soils (conservatively estimated to be 4,000 drums and 1,000 cubic feet of soil);
- installation of a RCRA cap over the landfill;
- installation of a soil-bentonite slurry wall vertical barrier;
- dewatering the inside of the slurry wall, and treatment and discharge of ground-water;
- installation of a fence around the landfill area;
- access restrictions;
- ground-water monitoring;
- a contingency for ground-water cleanup if ground-water remedial action goals may be exceeded at the Site boundary.

1988-1989: A group of PRPs, who formed the FWCC, completed the lagoon removal, in accordance with a UAO issued by EPA in 1988.

1990: EPA approved the FWCC's Construction Completion Report for the lagoon removal. EPA conducted additional test pit excavations and removed and staged 500 drums of waste. EPA initiated the routine ground-water monitoring program, which concentrated monitoring south and east of the landfill and former lagoons.

1993: The 1990 test pitting study confirmed that most of the drums were empty or contained mostly a solid residue of industrial waste. In addition, ground monitoring indicated that the ground-water movement was slower than expected and that the degree of ground-water contamination was more limited than expected. In response to this, in 1993, EPA modified the 1988 ROD with an Explanation of Significant Difference (ESD), which revised the ROD requirements as follows:

- the slurry/dewatering system was eliminated;
- reemphasis of the potential to implement a ground-water treatment system to in the case of an exceedance of action levels;
- some of the excavated material in source areas could be disposed in an approved hazardous waste landfill instead of being incinerated.

The FWCC removed hot spots of buried drums, including the 500 drums staged by EPA, and visibly contaminated soil, in compliance with an administrative order on consent issued by EPA in 1993. The FWCC took over the ground-water monitoring effort from MDEQ, who conducted the sampling in 1991 and 1992.

1995: 12 PRPs, who formed the FWCC, agreed to implement EPA's final selected remedial actions in a Consent Decree with EPA. Ground-water was found to be highly contaminated at a monitoring well north of the landfill (MW95-1S).

1995-1997: The FWCC completed construction of the landfill cap and gas venting system, took over ongoing ground-water monitoring, initiated the investigation of the plume north of the landfill, and purchased an additional 80-acres of property north of the landfill, which was used as a soil source for the landfill cap, and which is largely underlain by the contaminant plume migrating north from the landfill.

1997: EPA and MDEQ conducted the pre-final inspection for the landfill cap. EPA issued a Preliminary Closeout Report, and Five-Year Review Report.

1997- present: The FWCC has conducted long-term ground-water monitoring, maintenance of the Site fence and landfill cap, and a phased investigation of the ground-water contamination north of the landfill.

1999: Forest Township acquired ownership of the Site property, including the 80-acres of property to the north , which had been annexed to the Site.

August 2001: EPA and MDEQ conducted a site inspection of the landfill cap and fence. No problems were identified.

III. Background

Physical Characteristics

The Site is located on East Farrand Road near Otisville, in Forest Township, Genesee County, Michigan (see Attachment 1). The Site covers 112 acres. A capped former landfill covers 15 acres of the Site and the combined area of nine lagoons formerly covered a total of about 1 acre (see Attachment 2). In around 1997, the FWCC purchased 80-acres north of the landfill where a VOC-contaminated plume has been detected (clean topsoil in this area was used for construction of the landfill cap). Part of the additional 80-acres is wetland and part was formerly used for farming. The 80-acres has not been fenced, but usage restrictions have been imposed through notices on the deed. Many soil borings and ground-water monitoring wells have been placed on the 80-acres.

Land and Resource Use

The property west of the Site is used for farming. Undeveloped wetlands are adjacent to the east and north boundary (see Attachment 3). These wetlands drain into Butternut Creek, which flows within 100 feet of the southeast corner of the Site property. The area of the Site east and north of the landfill drains into these wetlands. There is a small man-made lake approximately 1000 feet north of the Site. Part of the 80-acres drains into this lake and part the wetland north of the Site. A number of houses are located within one-half mile of the Site along Farrand Road, Lake Road, and Harris Road. The houses are generally widely spaced. Twenty-nine residential wells have been identified located within about one-half mile of the Site and 80-acre boundaries (see Attachments 4 and 5).

History of Contamination

The Site landfill contains an estimated 260,000 cubic yards of waste and soil. Wastes disposed included waste oils, plating waste, metal sludges, brewery waste, sewage sludge, resin and paint waste, septic tank waste, phosphate-zinc waste, spent sulfuric acid, caustic pipe cleaning water, sauerkraut brine, fly ash, and wastes containing PCBs and PBBs. Apparently most liquids were disposed in the lagoons, although disposal into the landfill and onto the surrounding ground may have occurred. Drummed waste were buried in the landfill. Incoming wastes was apparently not closely screened, and the landfill area was managed in a very haphazard manner with trenches dug randomly and filled with a mixture of wastes.

The following three disposal events were of special concern:

1. June 1974, disposal of sludge, residual products and structural wastes from the

Agrico Chemical Warehouse fire[3];

2. July 1975, disposal of PCB-contaminated roofing material; and

3. December 1975, disposal of an estimated 8 cubic yards of PBB-contaminated cattle feed. These three disposal events were under the direction of the MDNR and the GCHD, and the prescribed disposal methods included burial of the wastes to 8 feet deep and covering with clay or concrete. Drummed wastes were buried in the landfill. The State of Michigan did not renew the permit in 1978 due to various violations at the landfill.

The hydrogeology is irregular in the vicinity of the Site, but generally there is a surficial layer of fine sandy loam and silty clay, and the following three hydrogeologic units: a shallow sand aquifer which is generally 10 – 30 feet below ground surface , a clay or silt till confining unit, and a deep sand and gravel aquifer which is generally 50 – 80 feet below ground surface. Geological cross sections of the lagoons (see Attachment 6) combined with information in the Final Record Drawings, Geraghty & Miller, 1990, indicate that the bottom of the lagoons may not have penetrated the surficial silty clay layer. However, disposal was deeper in the landfill. A bulldozer operator stated that barrels had been buried in the landfill to depths of 20-30 feet, sometimes below the water table. This suggests that some of the burial may have been below the surficial silty clay layer and into the shallow sand aquifer. Because there was no dewatering, it is believed that only a small percentage of the wastes were deposited below the water table. Saturated conditions were observed in 2 of the 15 test pits excavated during the RI probably due to perched water. The landfill was not significantly elevated above adjacent properties before construction of the cap.

Basis for Taking Action

An RI was conducted in three phases from June 1984 through April 1987. The RI focused on characterizing the lagoon contents, the landfill contents, the hydrogeology, surface soil, surface water, sediment and ground-water quality. Except as noted in the following discussion, all samples collected for contaminant analysis during the RI were analyzed for the target compound list (TCL) organics,[4] and the target analyte list (TAL) inorganics[5]. A smaller number of targeted samples were also analyzed for

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[3] Methyl parathion, malathion, aldrin chlordane and other herbicides are known to have been used or produced at Agrio Chemical, although it is not known whether the wastes contained these chemicals.

[4] The TCL organics include VOCs, SVOCs, pesticides and PCBs included in the parameter list for routine analysis in EPA's Contract Laboratory Program.

[5] The TAL inorganics include inorganic analytes (including metals, arsenic, cyanide) included in the parameter list for routine analysis in EPA's Contract Laboratory Program.

polybrominated biphenyls (PBBs), and some samples of landfill content were analyzed for dioxin/furans.

The lagoon content sampling during the RI included liquid samples from 3 of the 9 lagoons, surface sludge/sediment samples from 4 of the lagoons, composite soil samples from each of the 5 dry lagoons, and 30 subsurface soil samples from 6 of the lagoons. Surface sludge/sediment and liquid samples were also analyzed for PBBs in addition to TCL organics and TAL inorganics. The sample results for lagoon sludge and soils indicated that lead (up to 5,170 mg/kg) and chromium (up to 66,500 mg/kg) were a human health threat. The sample results for subsurface soils detected 1,1,1-trichloroethane (up to 15,000 mg/kg); tetrachloroethylene (up to 12,000 mg/kg); ethyl benzene (up to 420 mg/kg); and toluene (up to 320 ug/l). These VOCs were also detected in ground-water.

The landfill was covered with vegetation and native soil, but refuse was exposed in several places. An estimated 100-200 deteriorating drums were exposed on the surface of the landfill, which presented an acute risk to trespassers. During the RI fifteen test pits were excavated into the landfill. The test pits locations were identified based on file information, and from the results of magnetometer and resistivity surveys, and surface soil data. The test pit investigation identified some areas of general refuse, drummed liquid hazardous wastes and solids, PBB-contaminated cattle feed, fire debris, and contaminated soil. Many of the drums were sitting within perched water tables.

In landfill content sampling, a number of the VOCs were detected at very high concentrations, including: benzene, chlorobenzene, ethylbenzene, methylene chloride, tetrachloroethylene, trichloroethylene, vinyl chloride, toluene, acetone, 2-butanone, 4-methyl-2-pentanone, and xylenes. These VOCs have also been detected in ground-water. There were also very high concentrations of lead (up to 9,560 mg/kg) chromium (up to 2,640 mg/kg), zinc (up to 26,200 mg/kg), phenol, and PBBs (up to 4,900 mg/kg), as well as some polyaromatic hydrocarbon and phthalate compounds (see Appendix A of FS). However, the landfill contents were not completely characterized during the RI. Dioxins and furans were also analyzed and were detected at a maximum equivalent tetrachlorodibenzodioxin (TCDD) concentration of 0.2 ppb, which was below the cleanup action level used for TCDD at the time of 1.0 ppb.

Surface soil sampling included collection of 20 composite samples, two composites from roads used for Site access, and 15 grab soil samples from suspect disposal areas (see Attachment 2). These samples were analyzed for PBBs in addition to TCL and TAL parameters. A number of TAL parameters exceeded the range of background concentrations. A number of polyaromatic hydrocarbons, PBBs, phthalates, and pesticides were also detected.

Surface water and surface sediment sampling included collection of samples from 13 locations during two phases (see Attachments 7 – 10). The locations included nearby ponds, wetlands, and Butternut Creek. Seven phase I surface water and seven phase I

sediment samples were also analyzed for PBBs. The second phase of surface water and sediment samples were only analyzed for VOCs, metals and cyanide (not for PBBs, SVOCs, PCBs or pesticides). An impact from the Site was not identified from the surface water or sediment sample results.

Tissue samples were collected from 6 mammals and analyzed for the TAL and TCL parameters, and PBBs. An impact from the Site was not identified from the results (see Attachments 11 and 12). Separate composite tissue samples were collected for bluegills and yellow perch, and were analyzed for 17 organic compounds and seven metals. No organic compounds were detected. An impact from the Site was not identified from the results.

The RI included installation of 23 ground-water monitoring wells, with geological characterization of the borings. Ground-water sampling was conducted in three phases, with 14 samples collected during phase I, 22 during phase II, and 29 during phase III. Relative to the metals analyses, phase I included only analyses of unfiltered metals, phase II included analyses of filtered and unfiltered metals, and phase III included only filtered metals analyses. The RI water level survey indicated that ground-water in the shallow aquifer migrates from west to east and southeast from the Site (see Attachment 13, note that the only monitoring well north of the Site was screened in perched ground-water). The RI data demonstrated that the shallow aquifer east and southeast of the lagoons, and landfill was contaminated by cyanide, dissolved solids, high pH, metals, several VOCs, 4-methylphenol, and 2-methylphenol; but the contamination did not appear to extend far off-Site. The VOC, 4-methylphenol and 2-methylphenol contamination appeared to be most concentrated near shallow monitoring wells east of the former lagoon area, MW84-2S and MW85-1S, but only relatively low concentrations of VOCs were detected. The only detections from the RI sampling exceeding the present Safe Drinking Water Act Maximum Contaminant Levels (MCLs) were 38 ug/l of methylene chloride in MW84-2S, and 11 ug/l of trichloroethylene in MW85-1S, but even these detections were not repeated in more than one phase of sampling in the same monitoring wells. No VOCs were detected in deep sand and gravel aquifer monitoring wells.

It is likely that shallow ground-water in the eastern portion of the Site discharges to wetlands. A conservative model used in the RI predicted that contaminants detected in ground-water east and south of the landfill and lagoons would be below federal Ambient Water Quality Criteria before reaching the wetlands. In other areas of the Site, it is possible that the shallow ground-water recharges deep sand and gravel aquifer. However, an impact on the deep sand and gravel aquifer was not apparent from the RI data. Most residential wells in the area are screened in bedrock aquifers, which provides additional protection to these wells, but some are probably screened in the shallow sand aquifer and deep sand and gravel aquifer. In 1985, 11 residential wells were sampled and no impact from the Site was detected. However, arsenic exceeded its new MCL in three residential wells (concentrations of 29-39, 34-39 and 12 ug/l were obtained).

An air screening survey conducted during the RI did not detect elevated ambient air concentrations in the vicinity of the Site.

In 1995, high VOC concentrations were unexpectedly detected in a new monitoring well north of the Site. It was previously believed that all the contaminated ground-water migrated to the east from the landfill. This contamination north of the landfill has been the subject of phased investigations from 1996 through the present. It has been found that part of the contaminant plume has migrated north from the landfill in the shallow aquifer, and part migrates into the deep sand and gravel aquifer and then to the northwest away from the Site. When VOCs were detected in the deep sand and gravel aquifer near the property boundary of the 80-acres, EPA required sampling of nearby residential wells to the north and west of the Site. These residential wells were sampled in 2001 and 2002 and analyzed for VOCs.

IV. Remedial Actions

Remedy Selection

1984 Interim Remedial Measure ROD: This ROD required construction of a fence around the Site.

1986 Operable Unit ROD: The 1986 ROD required the following:

- removal, treatment and off-Site disposal of approximately 110,000 gallons of aqueous lagoon waste;
- excavation and off-Site disposal of all (approximately 4,000 cubic yards) contaminated sludges, sediment, and soil from lagoons 2, 3, 4, 6, 7, and 8 (no action was required for lagoons 1, 5, and 9);
- disposal of excavated sludges, sediments and soil at a RCRA permitted double-lined landfill;
- soil cleanup to 10^{-6} for carcinogens, and to a hazard index of 1.0 for non-carcinogens assuming an soil ingestion rate of 0.1 gram/day.

1988 Design Analysis Report: Among other requirements, the Design Analysis Report identified parameters specific action levels for the lagoon excavation.

1988 ROD as Revised by 1993 ESD : The 1988 ROD as revised by the 1993 ESD requires the following:

- removal and off-Site treatment of areas of concentrated drums and associated saturated contaminated soil in the landfill (conservatively estimated to include 4,000 drums of waste and 1,000 cubic yards of soil), including air monitoring to assure compliance with the Clean Air Act and Michigan Air Pollution Control Act, and storm water control during excavation;
- construction of a RCRA cap over the landfill (in accordance with RCRA the cap must minimize migration of liquid through the landfill, function with a minimum of maintenance, promote drainage, minimize erosion, accommodate settling, and be

less than or equal to the permeability of the natural subsoils present);
- maintenance of the fence around the Site constructed in 1984, and construction of a separate fence around the landfill;
- deed restrictions to prevent excavation of soil and/or landfill contents, and use of ground-water for drinking on the Forest Waste property and areas immediately surrounding the Site;
- ground-water monitoring, including analyses for TAL and TCL parameters, and for nitrate, nitrite, specific conductivity, and alkalinity ; and
- implementation of a ground-water treatment system if one of the following action levels are exceeded (on an average annual basis) in monitoring wells at the Site boundary (MW85-1S and MW85-2S) for drinking water protection, or upgradient from wetlands (MW86-2S, MW86-3S, MW86-4S) for aquatic protection:
  - MCLs;
  - lifetime health advisories in ground-water at the Site boundary;
  - 10^{-4} carcinogenic risk level in ground-water at the Site boundary;
  - non-carcinogenic risk index exceeding 1.0 in ground-water at the Site boundary;
  - Federal Ambient Water Quality Criteria;
  - State of Michigan Surface Water Quality Guidelines for Protection of Aquatic Life.

1995 Consent Decree: The 1995 Consent Decree Scope of Work (SOW) contains the following more detailed requirements:

- Fence around landfill: the fence around the landfill shall be a six foot high chain link fence topped with three stands of barbed wire, and a double 12-foot wide swing gate. Warning signs (containing a local contact's telephone number) must be posted at the gates and at 200 foot intervals along the fence.
- Deed restrictions: The SOW clearly states that the deed restrictions should prohibit development of the whole Site, including excavations, construction and drilling, and that the restrictions should be permanent, except that the restrictions on drinking water wells could be lifted if contaminant levels fall below the cleanup standards.
- Ground-water monitoring: The SOW required that for the first five years ground-water monitoring would be in accordance with the November 1989 Groundwater Monitoring Manual prepared for EPA by CH2M-Hill, Inc., as supplemented by Attachment 1 to the SOW (and as required by EPA). This included quarterly sampling of 11 shallow monitoring wells, and annual sampling of 6 monitoring wells. These monitoring wells were located upgradient of the landfill, between the landfill and former lagoons, downgradient of the lagoons, and near the east property boundary. Target VOCs and metals were to be analyzed quarterly, and the full TCL VOCs, TAL inorganics, and some general chemistry parameters were to be analyzed annually.
- Action levels for ground-water treatment: The SOW established as Site specific action levels (see Attachment 14).
- Ground-water cleanup: The SOW provides that the contingent remedy is a

ground-water extraction and treatment system, and that this system must contain the contaminated ground-water on-Site.

- Landfill Cover: The SOW requires that the cover be equivalent or superior to the following (from bottom to top layer):
  - a minimum 6 inch thick grading layer to provide the required slope and a stable base for the cover;
  - gas venting and treatment to prevent gases from migrating from the Site and from impacting the integrity of the cover;
  - a minimum 2 foot thick clay layer complying with Michigan Act 64 requirements;
  - a 60 mil high density polyethylene liner;
  - a minimum 12 inch thick drainage layer composed of pea gravel with a 6-ounce geo-textile filter-fabric placed above it;
  - a minimum 2 foot thick soil cover layer;
  - a minimum 6 inches of topsoil;
  - revegetation.
- Characterization of landfill gas emissions; and
- A contingency to reduce or eliminate landfill gas emission if they are found to cause an explosion hazard or a risk to human health outside of the landfill boundaries exceeding a lifetime incremental cancer risk of 10^{-6} or an hazard index of 1 for non-carcinogens.

Remedy Performance/Implementation

1. Quality Assurance/Quality Control of Data:

All analytical data generated for the RI, cleanup verification sampling, long-term ground-water monitoring, and the investigation of the plume north of the landfill, have been collected in accordance with procedures defined in EPA-approved sampling plans and a Quality Assurance Project Plans (QAPPs).

2. 1984 Site Fence construction: A seven foot chain-link fence with 2 strands of barbed wire was constructed around the Site as shown the Attachment 15. According the On-Scene Coordinator's Report, the fence met or exceeded specifications. As can be seen the fence did not enclose the entire property. However, no one has ever reported waste disposal on the portion of the property outside of the fence, except for a small portion of the landfill extended beyond the fence. The fence was relocated outside of the landfilled area after construction of the landfill cap.

This fence has not been included in CRA's semi-annual inspections of the landfill and fence around the landfill.

3. 1988-1989 Lagoon Removal: The FWCC subcontracted the lagoon removal work to Chemical Waste Management, Inc. The EPA remedial project manager, and an EPA contractor provided oversight. According to the Substantial Completion Report,

Geraghty & Miller, Inc., April 1990, standing liquids were pumped out and sludge and soil excavated and solidified. 9,140 tons of solidified waste and soil were disposed of at the Chemical Waste Management/CID Landfill, Calumet City, Illinois. Hazardous investigation waste was also disposed at this landfill. 56,922 gallons of liquid were disposed at CyanoKEM, Detroit, Michigan. Non-hazardous investigation waste was disposed at Woodland Meadows Landfill, and a small amount of decontamination water was disposed of at the City of Vassar wastewater treatment plant. Samples collected for approval of disposal were analyzed by Burmah Labs, Pontiac, Michigan.

The extent of initial excavation in each lagoon was specified in the Design Analysis Report. Solids were excavated to this depth, and then five confirmatory soil samples per lagoon were collected from the base of the excavation. In addition, samples were collected of any contaminated-appearing material or soils. If a sample exceeded an action level, another 6-inch layer was excavated. Sometimes more soil was excavated if odor or visual appearance indicated that it was likely to be contaminated. Following each phase of excavation, confirmatory samples were collected, and the procedure repeated until the soil action levels were achieved (except some locations EPA agreed not to require further excavation even thought a parameter somewhat exceeded the action level). As a result of these procedures, the removal activities were conducted over multiple construction periods, and exceeded the amount of excavation estimated in design documents at each lagoon except Lagoon 2. Confirmatory samples were analyzed for a target compound list organics and four metals. In general, the lagoons were cleaned up to the action levels in the 1988 Design Analysis Report or to CLP CRQLs, whichever was higher.

The entire lagoon area was backfilled, graded to a target slope of 2%, covered with 4-6 inches of top soil, and seeded. No soil was brought onto the Site to complete the grading.

4. Drum and Hot spot Removal from Landfill: In 1990, Donahue & Associates, Inc. (Donahue), under contract with the U.S. Army Corps of Engineers, excavated ten trenches into the landfill with a cumulative length of 702 feet to assess the location and approximate number of drums in the landfill, and to assess the extent and character of soil contamination. Donahue removed 1,003 drums, of which 503 with sufficient structural integrity were overpacked and placed in a drum staging area for characterization. The remaining 500 drums were backfilled into the trenches.

In 1992, the FWCC removed and disposed of the staged drums. The FWCC prepared a Drum Removal Action SOW, which defined trench boundaries where additional drums were to be removed based on the results of soil borings, test pits, and a magnetometer survey. In 1993 and 1994, the FWCC excavated the defined trench areas reportedly going beyond the defined vertical trench planes to remove clusters of drums at the trench walls, and also removed any drums visible from the surface. Reportedly, it

became apparent that there were specific drum disposal locations used by the landfill operators. In total the FWCC removed 3,188 overpacks containing excavated drums and 1977 cubic yards of visibly contaminated soil.

5. 1996-1997 Landfill Cap and Landfill Fence Construction: The extent of the landfill was delineated based on an electronic terrain conductivity survey conducted along the perimeter of the landfill, and twenty landfill boundary confirmation borings conducted by Donahue in 1990.

The FWCC contracted with Roy F. Weston, Inc. as the general contractor for the landfill cap construction, and contracted with McLaren Hart for construction oversight and quality assurance. McLaren Hart prepared a Closure Report Forest Waste Site dated November 20, 1997. CH2M-Hill, Inc., provided on-Site construction oversight for EPA. The Construction QA/QC appears to have been rigorous.

According to the Closure Report a construction quality assurance project plan was prepared for this project. The Closure Report indicates that the Site cap covered the entire area of landfilling, and consisted of the following layers from bottom to top:

- grading layer and compacted clay layer consisting of 19 lifts generally consisting of compacted clay soil (CL or CL/ML except a small number were SM/SC) (a lift was specified as a loose lift thickness of 8 inches and assumed compacted thickness of 6 inches;
- a gas vent layer consisting of one lift of sand (SP) (a lift was specified as a loose thickness of 14 inches and assumed compacted thickness of 12 inches)
- a CLAYMAX Geosynthetic Clay liner consisting of high density polyethylene with a nominal thickness of 60 mil. and adhering bentonite clay;
- a geo-textile along the perimeter of the Site;
- a cover layer consisting of five lifts of compacted clay soil (CL or CL/ML) (the first lift was specified as 14 inches with an assumed compacted thickness of 12 inches, and all other lifts were specified as 8 inches with an assumed compacted thickness of 6 inches for a total compacted thickness of 3 feet);
- a top soil layer consisting of approximately one foot of sandy loam soil; and
- vegetation.

The Closure Report indicates that hundreds of samples of the compacted clay layer, the gas vent layer and the cover layer were analyzed for soil gradation, classification, and compaction. Seven to 12 samples of each were run by McLaren and Hart for QA/QC testing. Nuclear density tests were also run on each lift. The Closure Report also includes daily soil inspection report forms completed in the field, some chemical analyses of the soil used for capping, and coefficient of permeability tests on the gas vent layer.

Regarding the geosynthetic clay liner and geonet, the Closure Report includes certifications and testing results from the manufacturer, certificates of acceptance of subgrade surface preparation for geomembrane installation from Geo-Synthetics Construction, Inc., and accepted by Roy F. Weston, Inc., trial seam reports from McLaren Hart, geomebrane quality assurance checklists from McLaren Hart, geomebrane repair logs from McLaren Hart, quality assurance testing geomebrane seam peel and tear test results by TRI/Environmental, Inc., and verification of material properties by Precision Environmental Laboratories. There were also organic matter tests on the cover soil.

In the June 30, 1997 Preliminary Close Out Report, EPA concluded that the cap and fence construction was consistent with the ROD/ESD requirements, and with the 100% Design Report. All outstanding punch list items from the prefinal inspection were addressed by the time of the final inspection on September 24, 1997, and EPA approved the Completion of Construction Report in a letter dated January 23, 1998.

System Operations/Operation & Maintenance

Since the landfill cap and fence have been constructed, they have been inspected at least semi-annually in accordance with the Operation & Maintenance Plan (McLaren Hart Environmental Engineering Corporation, August 1995). No significant maintenance problems have been observed.

V. Progress Since the Last Review

The purposes of the landfill cap were to eliminate the direct contract threat, and to reduce generation of contaminated landfill leachate, which migrates into the ground-water. The Closure Report indicates that the entire delineated landfill area was covered. According to data in the RI, this eliminated the potential for exposure to the most contaminated surface soil after removal of contaminants in the lagoons.

At this time there is not enough ground-water data to assess whether the generation of contaminated landfill leachate has been substantially reduced. If generation of contaminated leachate has been substantially reduced, it is possible that this will be evidenced by a large drop in the concentration of contaminants in the closest downgradient monitoring wells. The monitoring data does show a large change in VOC concentrations in monitoring wells near the landfill between April 1999 and June 2001, but the results are mixed, as shown in the following summary (see Attachment 16 for well locations):

- MW95-1S: BETX decreased from 14,100 to 2,910 ug/l; total chlorinated VOCs increased from 390 to 11,100 ug/l (mainly due to dramatic increases in 1,1-dichloroethane, chloroethane, and vinyl chloride);
- PZ96-5S: BETX decreased from 5,500 to 16 ug/l; ketones decreased from 2,130

ug/l to ND; total chlorinated VOCs decreased from 340 to 64 ug/l;

- PZ96-11: BETX decreased from 4,500 to 800 ug/l; ketones decreased from 3,700 to 880 ug/l; total chlorinated VOCs increased from 470 to 1,340 ug/l (due to increases in 1,1-dichlorethane, chloroethane, and vinyl chloride);
- MW99-1S: BETX decreased from 600 to 33 ug/l; ketones decreased from 1,180 ug/l to ND ; total chlorinated VOCs decreased from 4,100 to 350 ug/l;
- MW99-3S: BETX increased from 74 to 412 ug/l; ketones decreased from 2,800 to 250 ug/l; total chlorinated VOCs stayed essentially constant from 3,100 to 3,000 ug/l.

It is possible that the substantial reductions in all VOC concentrations in MW99-1S and PZ96-5S, indicates that a substantial narrowing of contaminant migration has occurred. If this is true, it could have been caused by a reduction in the ground-water mound below the landfill resulting from reduced infiltration through the landfill cap.

The semi-annual landfill cap and fence inspections by CRA have not identified any major problems with the cap or fence. During the Site inspection on August 20, 2001, EPA and MDEQ staff did not identify any maintenance problems with the landfill cap or fence.

Ground-water Monitoring, Investigation and Contingent Ground-Water Remedial Action:

The FWCC with input and oversight by EPA and MDEQ have conducted essentially two separate ground-water sampling efforts: one for monitoring for compliance with ground-water action levels at the eastern property boundary and wetlands (east plume); and another for investigation of the north plume. These actions will be discussed separately below.

East Plume Monitoring

The purpose of the east plume monitoring has been to detect migration of contaminants eastward from the former landfill and lagoon area through the shallow aquifer to the property boundary or to wetlands east of the Site, or downward into the deep sand and gravel aquifer. This monitoring was anticipated in the 1988 ROD and the Consent Decree. This effort was expected to be, has been, and in the future is expected to be routine. To date, it has verified that significant contamination is not migrating from the Site to the east or from the east part of the Site into the deep sand and gravel aquifer. As can be seen from Attachment 17, the ground-water monitoring required in the SOW was focused primarily on detecting ground-water contaminants migrating east from the lagoons.

The ground-water monitoring appears to have been conducted in accordance with SOW from 1990 until August 1995. The monitoring was conducted by EPA and MDEQ from 1990 until 1992, when the FWCC took over. The results of the water-level monitoring during this period consistently indicated migration of shallow ground-water from west to

east across the Site (see Attachment 13). In August 1995, EPA, MDEQ and the FWCC agreed to reduce monitoring from quarterly to semiannually, and to revise the monitoring network to include six new monitoring wells to provide a network of 16 shallow and 6 deep monitoring wells. This change focused more of the monitoring around all four sides of the landfill. In 1999, the monitoring was reduced to a once per year annual event. Starting in 2002, the monitoring was further focused to include only a few monitoring wells on the east side of the Site.

The most highly contaminated monitoring wells in 1990, were MW85-1S, and MW90-1S. Over the years, the detections in the east plume have, in general, gradually decreased, as summarized below:

- 1,1,1-trichloroethane in MW85-1S decreased from over 100 ug/l in 1990, to 9 ug/l in 1999, and to non-detect in 2001;
- trichloroethylene in MW85-1S decreased from approximately 5 ug/l in 1990, to 0.7 ug/l in 1999, and to non-detect in 2001;
- 1,2-dichloroethane in MW90-1S decreased from as high as 14 ug/l in 1990 to non-detect in 1999;
- 1,2-dichloroethylene (cis- plus trans-) in MW90-1S decreased from around 60 ug/l in 1990 to 3 ug/l in 1999; and
- vinyl chloride in MW90-1S decreased from as high as 7.3 ug/l to 0.9J ug/l in 1999.

However, the following detections are significant exceptions to this generally downward trend:

- 1,2-dichloroethane in MW84-1S increased from around non-detect in 1990-91, to 4-7 ug/l from1994-1998, and to 13-17 ug/l in sampling between March and June 2001. Although MW84-1S is not a boundary well, this exceeds the 5 ug/l action level for 1,2-dichloroethane.
- 1,2-dichloropropane in MW90-1S has remained almost constant between 1990 and 1999, ranging from 1 to 3.4 ug/l. It was detected at 2 ug/l in 1999. Although MW90-1S is not a boundary well, the range of detections is only marginally less than the action level of 5 ug/l.
- trichloroethylene in MW90-1S has increased from non-detect from 990 - 1996 to 1 ug/l in 1997, to 2 ug/l in 1998, to 4 ug/l in 1998, and to 5 ug/l in 1999. Although MW90-1S is not a boundary well, the 1999 detection equals the action level.
- vinyl chloride in MW85-2S has averaged right around the action level of 2 ug/l from 1991 through 2001 varying from non-detect to 5 ug/l. Vinyl chloride was detected at 2 ug/l in August and October 1998, 3 ug/l in March 1999 and non-detect in 2001.

There have been no exceedances of the action levels on an average annual basis at the boundary monitoring wells except for a slight exceedances for vinyl chloride in MW85-2S in 1993 (detections of 4.4, ND, and 3 ug/l), and in 1999 (3 ug/l). Recent detections at non-boundary monitoring wells at or exceeding the action levels included: 1,2-

dichloroethane detected at 13 ug/l in 1999 and 2001 in MW84-1S; trichloroethylene detected at 5 ug/l in 1999 in MW90-1S; and BIS(2-ethylhexyl)phthalate detected at 11 ug/l (action level is 6 ug/l) in 1999 at MW84-4S.

With the exception of arsenic, the filtered metal analyses conducted during the monitoring phase of the project indicates that metals contamination has not been a problem in monitoring wells designed to detect migration to the east from the Site. Filtered metals have been analyzed in preference to total metals during the monitoring phase, as well as in the phase II and III of the RI because elevated metals results from the phase I of the RI were attributed to suspended solids in the samples rather than to metal concentrations that are mobile in the aquifer.

Arsenic results have never exceeded the drinking water protection action level of 50 ug/l in any of the monitoring wells. However, concern about arsenic is raised because its MCL has been lowered to 10 ug/l. Arsenic concentrations exceeded 10 ug/l in "baseline" sampling conducted by CH2M-Hill in 1990 in the following monitoring wells : MW84-2S (16.6 to 18.5 ug/l); MW85-2S (13.5 to 15.5 ug/l); MW84-8D (10.5 to 13.2 ug/l); MW85-9D (20.5 to 24.9 ug/l); MW86-1D (25.8 to 28.1 ug/l). The arsenic detections in the deep sand and gravel aquifer (MW84-8D, MW85-9D, MW86-1D)) can not be attributed to the Site because the much more mobile VOCs have not been detected in deep sand and gravel aquifer samples. On the other hand relative to arsenic detections at MW84-2S and MW85-2S, historical VOC data indicates that these monitoring wells are located along a contaminant migration route from the lagoon area, and arsenic detections at these monitoring wells are elevated compared to other the shallow monitoring wells. This suggests that arsenic could be present above background concentrations in the vicinity of MW84-2S and MW85-2S because of migration from disposal area. A similar relationship of significant detections at MW84-2S and MW85-2S and non-detection in most other shallow monitoring wells, is also evidenced from filtered metals results in the RI, in annual monitoring events.

SVOCs and pesticide/PCBs were well characterized during the RI, and have been analyzed periodically during the monitoring period. SVOCs and pesticide/PCBs were analyzed in samples collected in March 1990, May 1993, March 1998, and March 1999. The monitoring has indicated that, with the exception of bis(2-ethylhexyl)phthalate (BEHP), SVOCs and pesticide/ PCBs have not been significant ground-water contaminants. In the RI, BEHP was detected in phase I monitoring well sampling at from 4.7 to 27 ug/l (compared to the MCL of 6 ug/l) in 4 shallow monitoring wells along the western boundary of the Site (generally considered upgradient). However, these detections were not confirmed in phases II or III sampling. BEHP was also detected in duplicate samples from MW85-9D at 10 and 15 ug/l. However, the presence of BEHP was not confirmed by the phase sample results. BEHP was not detected above its MCL in monitoring well sampling conducted in March 1990, May 1993, or March 1998. BEHP was detected at 11 ug/l at MW84-4S in March 1999, but MW84-4S is on the west side of

the Site and may be upgradient. Four carcinogenic polyaromatic hydrocarbons were detected in MW86-5S in May 1993 sampling:, (benzo(a)anthracene (1.2J ug/l); benzo(b)flouranthene (1.1J ug/l); benzo(k)fluoranthene (1.1J ug/l); and benzo(a)pyrene (1/2J ug/l)). However, these parameters were not detected in analyses of samples collected from that monitoring well in March 1998 or March 1999, nor in upgradient monitoring wells.

Even though PBBs are known to be a major contaminant in the landfill, PBBs were not analyzed in ground-water during the RI, and have not been analyzed in monitoring wells on the east side of the Site during the monitoring phase.

North Plume Investigation

In December 1995, elevated VOCs were detected in the new shallow monitoring well located north of the landfill (95-1S). Thousands of ug/l of acetone, toluene, 2-butanone, 4-methyl-2-pentanone, ethyl benzene, and xylene, and hundreds of ug/l of 1,1-dichloroethane and methylene chloride were detected in 95-1S. Some phenolic compounds and arsenic were also elevated. At the start of the north plume investigation, it was generally expected that the investigation would simply verify that the north plume was a minor release that would naturally attenuate before migrating far from the Site. Unfortunately, the contamination migration route of the north plume has been more complicated and extensive than expected, and as a result the FWCC is still working on delineating the plume. Once the plume is delineated, and enough other data is gathered, remedial actions will be evaluated. Even though the Consent Decree requires implementation of a pump-and-treat system, EPA is willing to consider use of other remedial technologies before requiring an action to be implemented. EPA will either require some type of active remedial measure to address the north plume, or require that it be monitored until it no longer presents a significant health threat.

In general, ground-water analyses during the north plume investigation has included analyses of only VOCs and parameters to help assess natural attenuation. Because VOCs are the most mobile contaminants, they are best for delineating the extent of contamination. We will need to characterize other parameters once the extent of the plume has been delineated.

The north plume investigation has been conducted in phases. The results from each phase of investigation have been reviewed by the FWCC, MDEQ and EPA, and concurrence gained on a proposal for further investigation before proceeding to the next phase. As a result of this procedure and because the hydrogeology is complex and the plume more extensive than expected, the investigation of the VOC plume migrating north from the landfill has been a prolonged process. However, this procedure has ensured that Agency staff have input into each phase of the investigation. Vertical aquifer sampling with VOC analyses using a field laboratory has been conducted during

installation of each boring or monitoring well at a new location. This procedure has provided field data for screening monitoring wells in the most impacted depth of the aquifer, and frequently has expedited the project by enabling the installation of additional well-placed monitoring wells before the drilling contractor demobilized.

Major sampling phases have included:

- January 1996: seven peizometers were installed (the results indicated that a VOC contaminant plume was migrating north from the landfill;
- March - May 1996: eight temporary well points and one peizometer were installed and sampled;
- September 1996: three peizometers and eleven temporary monitoring well points were installed and sampled;
- May 1997: 14 temporary monitoring points and twelve piezometers were installed and sampled;
- June 1997, September 1997, December 1997, and March 1998: water level surveys were repeated using the new permanent peizometers north of the Site;
- March 1998: ground-water sampling of permanent monitoring wells north of the Site was repeated;
- March - April 1999: Eight additional shallow aquifer monitoring wells, and the first two deep sand and gravel aquifer monitoring wells located north of the Site were installed, and water-level and water quality sampling were repeated (this phase of sampling identified contamination in the deep aquifer north of the Site, identified the need for further investigation in the deep aquifer, and identified the need to evaluate whether the shallow ground-water vents to the lake north of the Site);
- October 1999 - January 2000: Five additional shallow aquifer wells, six deep aquifer wells, and a staff gauge in the lake were installed ; three rounds of ground-water sampling for VOCs, two rounds for natural attenuation parameters, and focused sampling for PBBs were conducted (no PBBs were detected; VOC contamination was detected in the shallow aquifer in a monitoring well adjacent to the lake, and it was determine that further sampling was needed in the shallow aquifer and deep sand and gravel to delineate the plumes);
- May 2000 - September 2000: Five additional wells were installed in the deep sand and gravel aquifer and seven boreholes conducted into the shallow aquifer (this phase identified vinyl chloride contamination near the northwest property boundary of the 80-acres north of the Site in the deep sand and gravel aquifer, and provided documentation against a preferential pathway in the shallow aquifer to the lake and against a secondary source of contamination);
- January 2001 - December 2001: Four additional wells and one borehole into the shallow aquifer and one additional deep aquifer well were installed, residential drinking water samples were collected to address concern about off-Site migration of contamination in the deep sand and gravel aquifer, water level and water quality sampling was repeated, and five samples were collected of lake surface water and sediment pore water (the results regarding venting to the lake were not definitive);

- July 2002 - September 2002: Fifteen shallow aquifer, and at least eight deep aquifer boreholes were installed, water level measurements were repeated, monitoring well water quality sampling was conducted, residential drinking water sampling was repeated, and further sampling of pore water was conducted below the lake.

Sampling conducted between 1999 - 2002 has demonstrated that the north plume extends not only off-Site, but also beyond the 80-acre property which was annexed to the Site in the north in both the shallow and the deep aquifers. In the deep aquifer, VOCs exceeding action levels include vinyl chloride, 1,2-dichloroethane, and cis-1,2-dichloroethylene. 1,2-dichloroethane has been detected at from12 to 27 ug/l in MW99-13D (see Attachment 18 for monitoring well locations) compared to its action level of 5 ug/l. Cis-1,2-dichloroethylene has been detected at from ND to 190 ug/l in MW99-7D compared to its action level of 70 ug/l. Vinyl chloride has been detected at levels as high as 160 ug/l in MW99-16D and MW99-7D compared to its action level of 2 ug/l. Vinyl chloride has been the only VOC of significant concern in the deep aquifer near the property boundary of the 80-acres. Sampling conducted between August 2001 and April 2002, indicated that vinyl chloride exceeded its action level of 2 ug/l at off-property monitoring wells MW01-28D (annual average equaled 3.4 ug/l) and MW01-27D (annual average equaled 6.9 ug/l). In vertical aquifer sampling conducted in August 2002, vinyl chloride was detected at BH02-09.

For the shallow aquifer, the attached Table 1 compares VOC detections close to the landfill (within 900 feet) to detections farther from the landfill, and to drinking water protection action levels and Region 9 Preliminary Remediation Goals (PRGs) using data from 1999 - 2002. Close to the landfill, action levels are exceeded for benzene, carbon tetrachloride, 1,2-dichloroethane, 1,1-dichloroethylene, 1,2-dichloroethylene (total), dichloropropane, ethylbenzene, methylene chloride, 4-methyl-2-pentanone, toluene, trichloroethylene, and vinyl chloride. Whether because of biodegradation, dilution or slower migration rates, the list of VOCs exceeding action levels farther from the landfill is reduced to 1,2-dichloroethane, 1,1-dichloroethylene, 1,2-dichloroethylene (total), methylene chloride, and vinyl chloride.

In August 2002, vinyl chloride was detected at 52 ug/l, and cis-1,2-dichloroethylene at 310 ug/l in shallow aquifer boring BH02-07, which is about 200 feet north of property boundary of the 80-acres (see Attachment 16). VOCs were not detected farther north at BH02-02. The migration route of this shallow ground-water plume is still under investigation. Possible migration routes include continuing to migration north in the shallow aquifer, migration into the deep aquifer, or venting to the lake. To better delineate the extent of the shallow aquifer plume, additional borings are being conducted (proposed borings BH02-15, BH02-16 and BH02-17). One boring was conducted to monitor potential migration into the deep aquifer, and the result was non-detect for VOCs. In August 2002, MDEQ conducted sampling of pore water below the lake in a second attempt to locate where the ground-water vents to the lake, but were

unsuccessful. In addition, in August 2002, vinyl chloride was unexpectedly detected in vertical aquifer samples in the shallow aquifer at BH02-33 on the west side of the 80-acre property. It is unclear whether this contamination continues to migrate in the shallow aquifer or migrates into the deep sand and gravel aquifer.

There has been only limited sampling for parameters other than VOCs and parameters for evaluation of natural attenuation in the north plume area. VOCs have been used to delineate the plume because VOCs are the most mobile contaminant group. The extent of future sampling will be discussed with FWCC, the State and US EPA in the future.

Following is a list of results of concern for metals, SVOCs, and pesticide/PCBs:

- In December 1995, MW95-1S was sampled twice for SVOCs and once for filtered metals and pesticide/PCBs. Filtered arsenic was detected at 23.2 ug/l, which is above arsenic's present MCL. Iron was detected at 36,700 ug/l, which exceeds the aquatic protection action level of 1,000 ug/l. DDT was detected at 0.025 ug/l, which exceeds its action level of 0.00013 ug/l. No SVOCs exceeded the action levels.
- In March 1996, SVOCs, filtered metals and pesticide/PCBs were analyzed in MW95-1S. Arsenic was detected at 43.6 and 44.8 ug/l. Iron was detected at 37,300 and 38,100 ug/l. No pesticide/PCBs were detected, and no SVOCs exceeded action levels.
- In August 1998, MW95-1S was analyzed for filtered metals, and SVOCs. Filtered arsenic was detected at 44.5 and 44.9 ug/l, and iron and 12,100 and 12,600 ug/l. 2,4-dimethylphenol was detected at 29 and 34 ug/l compared to its new aquatic criteria of 12 ug/l. Naphthalene was detected at 29 and 60 ug/l compared to its action level of 29 ug/l.
- In October 1998, MW95-1S was analyzed for filtered metals, SVOCs, and pesticide/PCBs. Filtered arsenic was detected at 44.5 and 44.9 ug/l, and filtered iron at 12,100 and 12,600 ug/l. 2,3-dimethylphenol was detected at 29 and 34 ug/l. N-nitrosodiphenyl amine was detected at 29 and 60 ug/l compared to its new aquatic protection criteria (not in Consent Decree) of 13 ug/l, and the human health action level of 4.9 ug/l (Water Quality Criteria for protection of human health, water only, 10^{-6} cancer risk). Methoxychlor was detected at 0.64 and0.65 ug/l compared to the action level of 0.03 ug/l.
- In December 1998, MW95-1S was analyzed for TAL filtered metals, SVOCs, and pesticide/PCBs. Filtered arsenic was detected at 55.2 and 55.9 ug/l, and iron at 14,700 and 15,000 ug/l. Alpha-chlordane was detected at 0.0038 and 0.006 ug/l compared to its action level of 0.00053 ug/l. Dieldrin was detected at 0.031 and 0.034 ug/l compared to its action level of 0.0000315 ug/l. Heptachlor was detected at 0.025 ug/l in both samples compared to its action level of 0.0038 ug/l. Methoxychlor was detected at 0.26 and 0.54 ug/l compared to its action level of 0.03 ug/l. 2,4-dimethylphenol was detected at 38 and 41 ug/l compared to a new aquatic criteria (not in Consent Decree) of 12 ug/l.

- In 1999, MW95-1S, and MW95-1D were analyzed for TAL metals, SVOCs and pesticide/PCBs. Arsenic was detected in MW95-1S at 56.4 ug/l, and in MW95-1D at 19.2 ug/l. P,p'-methoxychlor was detected at 0.28 ug/l, exceeding the aquatic protection criteria of 0.03 ug/l. 2,4-dimethylphenol was detected at 39 ug/l in MW95-1S, exceeding the new (not in Consent Decree) aquatic protection criteria of 12 ug/l.
- In December 1999, MW95-1S, MW99-3S, MW99-16D, and MW99-6D were sampled for PBBs. No PBBs were detected. The method detection limit for the PBB analyses was 0.05 ug/l. Although no action level for PBBs is identified in the Consent Decree.

During this lengthy investigation process, EPA and MDEQ staff have periodically urged proceeding to the remedial action phase, but after review of the data concurred with the FWCC that additional investigation was needed before proceeding with implementation or evaluation of remedial actions. In a July 24, 1997 letter, EPA determined that the ground-water investigation had documented that ground-water contamination north of the landfill exceeds action levels from the 1989 Ground-water Monitoring Manual for acetone, 1,1-dichloroethane, toluene, methylene chloride, 1,2-dichloroethylene, vinyl chloride, and benzene, and called for preparation of a streamlined FS. In response to this the FWCC submitted a plan for natural attenuation modeling and related additional investigation. The Additional Investigation Work Plan (Conestoga-Rovers & Associates, October 1998) provided for submission of a report evaluating remedial alternatives for ground-water in the north plume area within 11 weeks from completion of the sampling in April 1999. However, since the date of that Work Plan three additional phases of investigation have been added.

The FWCC submitted a list of potentially applicable technologies in December 2001, and planned to proceed with more detailed evaluation of alternatives within the next couple months, but again unexpected results indicated that the contaminant plume still had not been characterized will enough to proceed to a detailed evaluation. In a May 28, 2002 letter, EPA determined that samples beyond or near the 80-acre property boundary exceeded action levels. However, instead of immediately requiring active remediation of the groundwater as required by the Consent Decree, EPA requested FWCC to evaluate ground-water remediation alternatives including active remediation, such as pump and treat. The FWCC has stated verbally that they plan to submit an evaluation of alternatives within a month after receipt of the validated data from the on-going phase of the investigation.

Exceedance of the action levels for aquatic life protection in monitoring wells adjacent to the lake provides another basis for evaluating remedial action alternatives, including pump and treat, for the north plume pursuant to the Consent Decree, assuming that the shallow aquifer contamination vents to the lake. Table 2 of this Five-Year Review provides a comparison of maximum detections from the north plume investigation in the shallow aquifer near the lake to the action levels for protection of aquatic life. The action

levels were exceeded for 1,1-dichloroethylene; and 1,2-dichloroethylene (total cis- and trans-).

The need for evaluation of remedial action alternatives to address the north plume is also reinforced by the fact that vinyl chloride concentrations substantially increased in two monitoring wells near the Site, and that vinyl chloride concentrations do not appear to attenuate farther from the landfill in the shallow aquifer.

Air Emissions: Ambient air sampling was conducted over an 8 hour period on October 26, 1984, as part of the RI. Samples were collected at five locations, including upwind, in the mid-lagoon area, in the drum disposal area of the landfill, and at the nearest residence. Samples were analyzed for 18 VOCs. No VOCs were detected in any of the samples at detection limits ranging of 0.004 to 0.02 ug/l.

During the lagoon removal action, air quality monitoring for VOCs was conducted throughout the duration of the excavation and solidification activities. Total VOC monitoring was conducted using a photoionization detector at hourly intervals at 6 locations surrounding the lagoons. Methylene chloride, tetrachloroethene, trichloroethylene, and vinyl chloride were analyzed using EPA method TO-1. No air quality problems were identified in the Revised Substantial Completion Report, Geraghty & Miller, Inc., April 1990.

During the drum removal action, TO-1 sampling for VOCs was conducted at four perimeter locations. Based on this data, neither EPA nor the MDNR Air Quality Division required corrective actions.

Air monitoring for dust and VOC emissions was conducted during the cap construction in accordance with requirements in the Health and Safety Plan. No emission problems were identified in the Closure Report Forest Waste Site, McLaren Hart, 1997.

Air sampling to characterize landfill gas emissions has not been conducted as required in the SOW. In addition, soil gas monitoring has not been conducted to assure that landfill gas is not migrating into off-Site structures. US EPA and FWCC believe this is very unlikely.

Deed and Access Restrictions:

Ownership of the Site property and the 80-acre parcel north of the Site was transferred to Forest Township in 1999. Deed restrictions have been filed with the Genesee County Register of Deeds for the Site property and the 80-acre parcel. The deed restrictions prohibit the following:

- interference with the remedial action;
- use of ground-water (other than for monitoring);

- all access to the landfill area, and excavation regrading or removal of soils in the landfill area, except as needed for sampling and maintenance;
- all construction unless approved by EPA and MDEQ;
- removal of soil outside the landfill area except for sampling; and
- all activities that may result in human exposures above MDEQ standards, or that would result in a release of hazardous substances.
-

Inasmuch as the Township owns the property, it has direct control over how and whether it is redeveloped.

Forest Township issues permits for usage of the property outside the landfill. In November 2000, Forest Township reported that parts of the property were being used for model airplane flying, archery, and paintball. No signs of improper Site access has been reported to EPA except that the Monthly Progress Report for May from CRA indicates that the gate to the landfill was being opened by removal of the gate's hinges. This was addressed by placing a chain and lock on the hinge side of the gate.

Forest Township has at least informally considered other development opportunities for the property, outside the landfill. Any such future use would have to be consistent with the remedy and existing site conditions. Buildings, roads, etc., are prohibited unless expressly approved by U.S. EPA.

Currently there are no formal ground-water usage restrictions on properties directly east of the Site, nor north or west of the 80-acre parcel. Certain limited portions of those areas have been impacted in either the shallow or deep aquifers, however, the drinking water wells in these areas are predominantly screened in the bedrock aquifer, which is separated by between 20 and 100 plus feet of clay from the deep aquifer. In addition, the relevant residential wells have been tested annually going back two years and all have been clean.

Risk Assessment Review

A risk assessment review is needed to assess whether the remedy remains protective considering new toxicity information. Only a screening level human health and ecological risk assessment was found to be necessary. For the human health risk screening, environmental concentrations or action levels were compared to the November 22, 2000, update of the Region 9 Preliminary Remediation Goals (PRGs). The PRGs are set at concentrations calculated to provide human health protection by assuring that the exposure rate will be less than or equal to the reference dose for non-carcinogens, and will not produce a lifetime increment cancer risk exceeding 1×10^{-6}. The PRGs are calculated using conservative exposure assumptions and toxicity factors from EPA's Integrated Risk Information System. Therefore, if the environmental medium or action levels are essentially equal to or less than the PRGs, we can be confident that

the remedy is protective considering new toxicity information. For the ecological risk screening, environmental concentrations or action levels were compared to conservative screening-level ecological benchmarks. Available background concentrations, and whether available data indicated or contraindicated a connection to the Site, were also considered in the risk screening.

1. Current and Future Human Health Risks from Air Emissions: Existing potential sources of air emissions, include the landfill and the contaminated ground-water. Generally, what is referred to as landfill gases are generated in landfills from anaerobic decomposition of organic matter. The landfill gas generally consists mostly of methane and normal air components, but also can carry VOCs that are present in the landfill. Landfill gases can be released to the atmosphere through the cap or through gas vents. Landfill gases can also migrate through vadose zone soil and enter nearby buildings through crawl spaces or cracks in slab or basement floors. This can cause a hazard both because of potential explosion hazard, and because of potential exposure to toxic VOCs. It is also possible for VOCs in shallow ground-water to migrate into and through vadose zone soils and enter nearby buildings through crawl spaces or cracks in flooring.

It is believed that the landfill generates very little gas because little easily degradable garbage was disposed of in the landfill and because the landfill is already over 20 years old. It is very unlikely that landfill gas is entering buildings via migration in the vadose zone because the nearest residence is about 1,500 feet away. For the same reason, any emissions from the landfill vent is likely to have only a very minor affect on nearby residents. In spite of these favorable conditions, no formal evaluation or sampling has been conducted to completely rule out the possibility that these exposure routes are be significant. These exposure routes would be a major concern if the Site or the 80-acre property in the vicinity of the landfill is developed for houses or buildings in the future. There is also potential for an acute health hazard to trespassers on the landfill if they vandalize the vents, or purposely inhale vent emissions.

Relative to migration of VOCs from ground-water into nearby buildings, there are no buildings east of the Site; so this is not presently a concern for the east plume. For the north plume, the investigation has demonstrated that VOCs have migrated into the deepest part of the shallow aquifer well before the plume reaches the boundary of the 80-acres north of the Site. Therefore, this migration route is also not a concern for the north plume. However, this exposure route would be a major concern if the Site or 80-acres north of the Site, are developed for houses or buildings in the future.

2. Future Risks from Exposure to Soil: It is well documented that highly contaminated materials remain in the landfill under the cap. Therefore, the landfill cap must be maintained, and access and usage restrictions enforced to prevent unacceptable risks from exposure to the landfill contents.

Outside of the landfill area, there has been an interest in development, including residential development. To screen risks from this type of development using available data, surface soil sample results from the RI (for soils that were not removed in the lagoon removal action or covered with the landfill cap) and the shallow soil sampling conducted by McLaren Hart in 1997, were compared to Region 9 PRGs for residential soil. The McLaren Hart sampling was conducted in response reports from nearby residents regarding locations of disposal outside of the landfill area. The available data was not collected in a statistically random fashion, and as a result a rigorous statistical evaluation of on-site and off-site contaminant concentrations should be not conducted.

This evaluation does not include the 80-acres north of the Site, which was used for farming during the period of operation of the Site as a disposal facility. There is no knowledge of systematic disposal on the 80-acres other than on the small portion of the landfill that extended onto this property and has been capped and fenced. There are some areas on the 80-acres where there is a collection of junk including a few barrels on the ground surface. This condition indicates that some haphazard disposal occurred on the 80-acre property.

In addition to this evaluation, the possibility that undetected hot spots of waste disposal still exist on the Site was evaluated. This appears to be unlikely based on review of available information. Efforts to identify waste disposal areas have included review of Site visits by MDEQ and GCHD staff during the period of operation, interviews with Site operating personnel, information requests to the owner/operator, interviews with nearby residents, surface water and sediment sampling, collection of 37 surface soil samples during the RI, and collection of nine surface soil samples by McLaren Hart. Nineteen of the RI surface soil samples were in areas outside of the landfill and lagoon removal action. Furthermore, the documentation demonstrates that the lagoon removal action was thorough, and the landfill well delineated.

Available on-Site surface soil analytical results from sampling outside of the landfill and lagoon areas has included:

- RI sampling including ten grab surface soil sample locations (phase 2 samples SL01, SL02, SL03, SL04, SL05, SL06, SL07/SL08, SL09, SL10, and phase 1 sample SL16), five composite surface soil locations (phase 2 samples SL12, SL13, SL14, SL15, and SL16/SL17), and two composite access road locations (phase 1 samples SL21 and SL22) (see attached Figure 3-1 from the RI for sample locations). These samples were analyzed for TAL inorganics, TCL organics, and PBBs.
- McLaren Hart sampling including nine composite surface soil sample locations in areas of suspected disposal. These samples were analyzed for TAL metals, and PBBs.

The results in these surface soil sample results were compared to the Region 9 PRGs for residential usage. 2-butanone, chlordane, DDT, DDE, and endosulfane were the

only organic compounds detected outside of the landfill and lagoon areas during the RI, but all the detections were well below the PRGs. No PBBs were detected in either the RI or McLaren Hart surface soil samples.

Only arsenic and iron exceeded any of the residential soil PRGs as summarized below (all units are in mg/kg):

Parameter	PRG RESIDENTIAL SOIL	BACKGROUND[6]	SURFACE SOIL SAMPLING RESULTS
Arsenic	0.39 (cancer 10^{-6}) 22 (non-cancer)	≤2 - 11	≤2 - 28
Iron	23,000	8,180-25,200	5,960 - 23,600

Iron was detected at a concentration essentially equal to the residential PRG in sample SB8 collected by McLaren Hart. However, the detection was within the range of concentrations in the background samples. Therefore, the iron concentrations detected are likely to be naturally occurring.

Arsenic was detected above its residential PRG in a number of surface soil samples. Four of the samples exceeded the range of the background samples (RI phase 1 sample SL17, RI phase 2 samples SL07 and SL013, and McLaren Hart sample SB-8). During the RI, arsenic was found at elevated concentrations in some source area samples (as high as 210 mg/kg in a sample from Lagoon 8, see Table A-5 of the RI, and up to 62 mg/kg in landfill waste samples, see FS appendix). The RI results indicate that the waste disposal is a potential source of some of the arsenic detected on the Site.

On the other hand, the surface soil arsenic detections are within the range of concentrations typical of U.S. soils (1-50 mg/kg according to Table 4-6 of the RI). In addition, the sample locations of the two highest arsenic detections (22 mg/kg at SL07 and 28 mg/kg at SL13) do not appear to be in locations likely to have been impacted by the known or suspected disposal. Therefore, it is possible that more extensive sampling would demonstrate that the on-Site arsenic concentrations are within Site-specific background concentrations.

If future development occurs subsurface contamination is also a concern because it is possible for subsurface soils to be brought to the surface. To investigate this concern the following table identifies subsurface samples that exceeded PRGs in the following

[6] This is the range of the background samples used in the RI (Table D11). Ten background soil samples were collected from one off-Site location, at one interval depths from zero to 10 feet below ground surface.

subsurface soil samples:

- Phase I RI lagoon surface samples from unexcavated lagoons 1, 5 and 9 (3 samples) These areas were probably covered during regrading. Results are in RI Tables D-14 and D-16. These samples were analyzed for TAL inorganics, TCL organics, and PBBs.
- Phase 3 RI subsurface soil sample results from unexcavated lagoons 1, 5 and 9, and from below the level of excavation in excavated lagoons (13 samples). Results are in RI Tables D-17 and D-18). TAL inorganics, and TCL organics.
- Confirmatory samples collected from the bottom of the excavations during the remedial action (31 samples). These results are tabulated in Revised Substantial Completion Report, Geraghty & Miller, Inc., April 1990. These samples were analyzed for TCL organics, barium, chromium, lead and nickel.

Again, only arsenic and iron exceeded any of the residential soil PRGs as summarized below (all units are in mg/kg):

PARAMETER	PRG RESIDENTIAL SOIL	BACKGROUND	SUBSURFACE SOIL SAMPLING RESULTS	CONFIRMATORY SAMPLING RESULTS
Arsenic	0.39 (cancer 10^{-6} 22 (non-cancer)	≤2 - 11	≤2 - 32	Not analyzed
Iron	23,000	8,180-25,200	4,450 - 24,200	Not analyzed

Iron exceeded the residential PRG by a minor amount in one sample near the surface in lagoon 9, which was not excavated, but it was probably covered during the final regrading. However, the iron detections were all within the range of background detections. Therefore, the iron concentrations are likely to be naturally occurring.

Arsenic exceeded the residential PRGs in a number of subsurface samples. However, the arsenic detections are within the range of concentrations typical of U.S. soils, and arsenic only exceeded the range in Site-specific background soils in 6 sampling locations. The three highest detections were in the three surface soil samples from the unexcavated lagoons 1, 5, and 9 (30-32 mg/kg). These surface soils were probably covered during regrading of the lagoon area.

Even though available data is favorable, a more systematic sampling and evaluation would be advisable before extensive development of the Site outside of the landfill area occurs, to better statistically evaluate arsenic concentrations, and to better evaluate subsurface contamination in areas where there would be extensive excavation. In addition, the potential for migration of landfill gas, migration of VOCs in ground-water into the vadose zone would have to be considered, and, of course, ground-water could not be used.

3. Current Risks from Exposure to Soil: Access to the landfill is restricted by a fence. Because the landfill is covered with clean soil even if a trespasser enters the landfill area, there will be no incremental risk from exposure to contaminated soil as long as the cap material is not removed.

Outside of the landfill area, the Site is under the control of Forest Township, who has allowed the area to be used for model airplane flying, archery, and paintball. These activities do not involve any significant disturbance of the soil, and participants would only be on the Site a few days per year (compared to 350 day/year used for derivation of the residential soil PRG). In addition, children in their youngest years (who have the highest assumed exposure rate) would most likely not participate. As a result, the exposure rate would be less than 1% of the exposure rate assumed in derivation of the PRGs, and, as a result, there is no significant health risk from exposure to soil contaminants from these activities. This is consistent with the conclusion in the RI that none of the soil samples collected outside of the landfill and lagoon areas identified a potential direct contact risk exceeding 10^{-6} for the trespasser scenario (see Figures 6-7 from the RI).

4. Future Human Health Risks from Ground-Water:

A number of the parameters exceed the PRG's screening levels, and therefore it is unclear whether the site presents a future human health risk through consumption of ground-water. The FWCC asserts the remedy is protective as long as the action levels articulated in the ROD are met. The State asserts that the risk should be compared to Part 201 criteria. The appropriate risk evaluation criteria remains an open issue.

Presently, deed restrictions prohibit usage of ground-water on the 80-acre parcel north of the Site. The 80-acres encompasses the great majority of the north plume contamination, but it has been found that some of the contamination migrates beyond this property to the west in the deep sand and gravel aquifer, and north in the shallow aquifer. Use of the shallow sand aquifer or deep sand and gravel aquifer from properties north or west of the 80-acres should be prohibited in order to avoid unacceptable exposures. Unacceptable exposures presumably would not exist after all ARARs are achieved.

Another concern is that PBBs are known to be present in the landfill but are not part of the required ground-water monitoring. It may be possible for PBBs to migrate off-Site in ground-water without being detected.

5. Current Human Health Risks from Ground-Water: Residences in the area of the Site rely upon private wells for their water supply. Most of the residential wells are screened in bedrock aquifers. This provides substantial protection to these wells both because of dilution, and because the bedrock aquifers appear to be hydraulically separated from the

deep sand and gravel aquifer by a significant confining lower till unit. Information on the thickness of the lower till unit from residential well boring logs north of the Site collected by Conestoga-Rovers & Associates (CRA) indicate that the unit is present in each available log and from 25 to 220 feet thick. The lower till unit was also encountered in each of the borings for the north plume investigation deeper than 80 feet, and in at least 4 RI borings. Four borings conducted during the north plume investigations confirmed that the unit was at least 10 feet thick near the northwest side of the 80-acre property.

It does not appear that there is a complete exposure route to residential wells south and southeast of the Site (see Attachment 4). The east plume contamination is limited to the on-Site shallow aquifer, which is only 10 to 30 feet below ground surface on the Site. This plume is migrating eastward off-Site where it is likely to vent to wetlands surrounding Butternut Creek. The residential wells in this direction are also protected by the distance from the Site (the nearest downgradient residential well is approximately one-half mile away), and the fact that contaminants leaving the Site have only minor exceedances of action levels for vinyl chloride (3 ug/l), and arsenic above the new MCL of 10 ug/l and possibly exceeding background (15-20 ug/l in MW85-2S). Based on this information, further sampling of the residential wells located south and east of the Site should not be necessary.

The residential well sampling results from the RI, confirmed the expectation that the residential wells were not impacted by the Site. No VOCs, SVOCs, pesticides or PCBs were detected in the eleven residential wells sampled during the RI. Ten of these residential wells were located south and southeast of the Site, and one was located northwest of the Site. The only metal detection of concern was arsenic, which exceeded the MCL in three of the residential wells. However, detections are not related to the Site.

Fourteen Residential wells have been identified north of the Site following VOC detections north of the landfill. These residential wells are shown on the Attachment 5. All except one of these residential wells are known to be screened in the bedrock aquifer. The depth of the one exception is not known and is under investigation. Even though the north plume investigation has demonstrated the presence of VOC contamination exceeding actions levels in both the shallow sand and deep sand and gravel aquifers beyond the property boundary of the north 80-acres, there is probably not a direct migration route from the contamination to the wells screened in bedrock because bedrock wells are protected by the lower till unit. Because of the uncertainty about how effectively the residential wells are sealed from shallow ground-water contamination, EPA and MDEQ staff believe that at least annual sampling of the residential wells that are screened in bedrock is necessary to ensure protectiveness until the plume is delineated. If the one residential well under investigation is screened in the shallow sand or deep sand and gravel aquifers, then this may need to be sampled more frequently to ensure protectiveness at least until the plume is delineated.

Ten of the residential wells located north of the Site were sampled in January 2001, and twelve were sampled in February 2002. All samples were analyzed for only VOCs. No VOCs were detected, which confirms that these wells are not being significantly impacted by the Site. The well-owners were informed of the test results. In addition, a fact sheet was prepared and distributed to the well owners and to other interested parties in March 2001.

There is also concern about current exposure to VOCs in the shallow contaminant plume via venting of the shallow ground-water to the lake and exposure in a wading scenario. However, at this point VOCs have not been detected venting to the lake. A number of samples of aquifer pore waters below shallow portions of the lake adjacent to the VOC plume, but no VOCs attributable to the Site have been detected. In addition, water-level measurements for evaluating whether the shallow ground-water vents to the lake have been indefinitive.

6. Ecological Risks: This Five-Year Review confirmed that the RI data sufficiently demonstrated that there was no significant identifiable ecological impact from the Site, and that further evaluation of ecological risks are not warranted. This is further explained below. The ecological risk evaluation can also be divided into two parts:

1. evaluation of risks to wetlands and Butternut Creek located east of the Site, which were evaluated during the RI; and
2. evaluation of risks from potential venting of contaminated ground-water in the north plume to the lake north of the Site.

These parts are discussed separately below.

Evaluation of Risks to Aquatic Life in Wetlands and Butternut Creek east of the Site

In the RI, risks to aquatic life in the wetlands and Butternut Creek east of the Site were assessed based on surface soil data, surface water data, sediment data, mammal tissue data, fish tissue data, and ground-water data. It was found that detections of certain parameters in surface water, sediment and mammal tissue exceeded the concentration range in the assigned background samples, but it was concluded in the RI that these detections could not be attributed to the Site. Therefore, no direct remedial action was performed in the wetland or Site drainage areas. It was also concluded in the RI that venting of contaminated shallow ground-water to the wetland was not causing a risk to aquatic life at that time. Further contamination of wetlands via erosion of contaminants from the Site was being addressed through removal of the lagoons, and capping of the landfill.

Continued venting of contaminated shallow ground-water to the wetlands was not expected to cause a risk, but to assure that the wetlands were protected in the future, the

ROD and Consent Decree SOW identified aquatic protection action levels to be met in monitoring wells downgradient from the Site and adjacent to the wetlands. The aquatic protection action levels were set at Michigan Rule 57(2) quality-based levels, or at the Water Quality Criteria for aquatic life protection if a Rule 57(2) level was not available. If these action levels were exceeded, then a pump-and-treat system must be initiated to contain the contaminated ground-water on-Site. This requirement is conservative because it does not take into account dilution or biodegradation in the wetland.

The RI samples were located based on proximity to the disposal areas and the drainage pathways from the disposal areas. Attachment 7 displays detections of inorganic constituents in surface water that exceeded the concentration range in the RI assigned background samples (SW201, SW207 and SW001). It appears that the Ambient Water Quality Criteria (AWQC, 1986) were exceeded for cadmium, chromium (VI), copper, iron and lead in SW003, but the high aluminum concentration in that sample indicates that the metals were probably associated with solids in the water and were not dissolved. The AWQC was also exceeded for iron and lead in SW005 which also had an elevated aluminum concentration, but not in co-located sample SW004 which had a much lower aluminum concentration. This again indicates that the elevated metals concentrations are probably due to solids in the sample. There were no reliable detections exceeding AWQC for organic constituents (see Attachment 8).

Attachment 9 displays detections of inorganic constituents in sediment samples that exceeded the concentration range in the RI assigned background samples (SD201, SD207, and SD001). The primary metals of concern for disposal in the lagoons were barium, chromium, lead, and nickel. Of these metals, the only constituent that significantly exceeded background concentrations was barium at SD002, SD003, SD007, and SD203 (90 - 365 mg/kg compared to 17-59 in background). The Consent Decree does not include a wetland protection action level for barium. The Quality Criteria for Water, 1986 concluded that a restrictive criterion for aquatic life appeared to be unwarranted because in most natural waters there is enough sulfate or carbonate to precipitate any soluble barium to a virtually insoluble and non-toxic form. Based on this information, we can conclude that the barium detections do not indicate a significant risk to aquatic life. There is an obviously elevated detection of arsenic in SD004 at 100 mg/kg, which is higher than any of the arsenic detections in on-Site soil samples. Because arsenic was not detected above background in SD002, SD003, SD004, SD005, or SD006, which are along the drainage pathway from the Site to SD004, it does not appear that the arsenic detection in SD004 is attributable to the Site.

Attachment 10 displays the detections of organic compounds in sediment samples from the RI. The low-level detections of methylene chloride, acetone, bis (2-ethylhexyl) phthalate, and PBB in SD204 and SD202 do not appear to be attributable to the Site because of non-detection of organics in upstream samples SD004, SD005, and SD006.

Attachment 11 displays detections of inorganic constituents in mammal tissue that exceeded the concentration range in samples from a study by MDNR, and Attachment 12 displays detections of organic constituents. Of the metals of concern at the Site, only zinc is identified as exceeding background (25-39 mg/kg compared to background of 12-16). However, EPA staff believe that this is a minor exceedance of background. The only organic constituents detected were isophorone, and 4,4'-DDE, neither of which were identified as major Site-related contaminants in other media. Therefore, further evaluation of the significance of these detections is not warranted.

Two composite tissue samples, one from three bluegills and one from three yellow perch, were analyzed for 17 organic parameters including PBBs, and seven metals. None of the organic parameters were detected. Zinc, copper and mercury were detected, but all were below State action limits. The copper and mercury were at trace levels.

To further assess aquatic risks especially from venting of the shallow ground-water into Butternut Creek, MDEQ conducted chronic toxicity evaluations on grab samples from Butternut Creek water at Gale Road, which is northeast of the Site from July 7-15, 1994, and September 15-21, 1995. The sample results indicated that on both test dates the Creek water was not chronically nor acutely toxic to *C. dubia.* This provide further evidence that the ground-water plume has not significantly impacted Butternut Creek.

Compliance with the ground-water action levels for aquatic life protection has been monitored for ground-water migration to the east from the Site using three monitoring wells located adjacent to wetlands east of the Site (MW86-2S, MW86-3S, and MW86-4S). There have been no exceedances of the wetland action levels in these monitoring wells. The parameters that have been elevated in east plume monitoring include 1,2-dichloroethane, 1,2-dichloropropane, trichloroethylene, vinyl chloride, bis(2-ethylhexyl)phthalate, and arsenic. Table 2, which was prepared for the north plume investigation, indicates that the aquatic protection action levels for 1,2-dichloroethane, and trichloroethane are more stringent than the current bench mark screening levels, and the vinyl chloride concentration in the east plume is infinitesimal compared to current bench marks. It is likely that similar results would be obtained for 1,2-dichloropropane because it is also a chlorinated VOC. For arsenic and bis(2-ethylhexyl)palate the drinking water action levels will provide sufficient protection to aquatic life from venting of the shallow aquifer. However, this may not be true for iron. The ROD action level for iron is 1,000 ug/l based on its federal Ambient Water Quality Criteria.

Evaluation of Risks to Aquatic Life from the North Plume

The RI did not identify the potential for VOC contaminants to migrate into the small lake north of the Site. At this time it is unclear whether there is any exposure to aquatic life from the north plume, because it has not been determined whether the portion of the north plume in the shallow aquifer vents to the lake north of the Site. However, because

there appears to be a strong possibility that the shallow aquifer vents to the lake, EPA has reviewed the aquatic protection action levels applying to the VOCs that may be venting to the lake and has determined that applying these action levels will be protective of aquatic life.

David Brauner, Ecologist for EPA Region 5, conducted a search for current screening-level bench marks for VOCs detected near the lake during the north plume investigation (see June 4, 2001 memorandum). Table 2 of this Five-Year Review compares the most stringent bench mark identified by Mr. Brauner with the action level for wetland protection from the Consent Decree and the maximum detection in ground-water near the lake. This comparison shows that for VOCs having aquatic protection action levels, these action levels are more stringent than the current benchmarks. Although chloroethane, 1,1-dichloroethane, and vinyl chloride do not have a wetland action levels, the maximum detections are less than the current bench marks. Therefore, applying the wetland action levels to ground-water near the lake will be protective of aquatic life in the lake.

MDEQ has promoted requiring compliance with Michigan's current ground-water/surface water interface (GSI) criteria, pursuant to Section 20120a(15) of Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451. The GSI criteria would apply to ground-water that is venting to surface waters. In practice it includes a generic action level of 15 ug/l for vinyl chloride, which is much less than vinyl chloride concentrations detected next to the lake (although it still has not been determined whether the ground-water vents to the lake). However, the GSI criteria was promulgated after the 1988 ROD, and under the federal Superfund law EPA can not require changes to ROD criteria, unless it is necessary to assure the protectiveness of the remedy. This issue is still under discussion.

VI. Five-Year Review Process

MDEQ was notified of the start of the Five-Year Review process during the fall of 2001. The FWCC, the Michigan Department of Community Health, and Forest Township were notified in September 2002. A notification of completion of this Review will be published in a local newspaper of general distribution. A copy of the Review will be distributed to MDEQ, FWCC, the Michigan Department of Community Health, the Genesee County Health Department, and Forest Township. A copy will also be available in the local repository at the Forest Township Library, 130 East Main Street, Otisville, Michigan, and at the US EPA, Region V Records Center, 77 W. Jackson Blvd., Chicago, Illinois. Copies can also be provided to other interested parties.

This Five-Year Review included a review of the following information: historical conditions; remedial action requirements; the extent of sampling conducted; quality assurance/quality control procedures; performance of the remedy, and anticipated future actions. Particular attention was paid to the following documents: Remedial Investigation

Report Forest Waste Disposal Site, CH2M-Hill, Inc., August 28, 1997 (RI); Record of Decision (ROD) documents; the Consent Decree Scope of Work (SOW); closure reports; ground-water monitoring reports; and additional ground-water investigation reports. Documents reviewed that are not presently in the Administrative Record are listed at the end of the report. A Site inspection was conducted by EPA and MDEQ staff on August 20-21, 2001. A screening-level risk assessment was also performed. The initial draft of the Five-Year Review was distributed to MDEQ and the FWCC September 20, 2002.

VII. Technical Assessment

- *Question A: Is the remedy functioning as intended by the decision documents?*

With one exception, the remedy has been implemented as intended in the ROD documents. The lagoon removal action was thorough in meeting risk-based cleanup levels. The drum removal action was successful in removing wastes contained in a large number of intact drums from the landfill. It is hoped that this resulted in a significant reduction in leaching of hazardous substances from the landfill. The landfill cap and fence were well-constructed, and are being adequately maintained. The cap and fence have eliminated the direct contact threat from the landfill, and should substantially reduce ground-water contamination from landfill leachate. Site usage and access restrictions are adequate to protect of public health. The ground-water monitoring of the east plume has complied with requirements in the ROD and Consent Decree SOW.

The one exception is that the 1988 ROD provides for prevention of use of the shallow aquifer for drinking water not only on-Site, but also in adjacent areas. Deed restrictions and ownership of the Site and 80-acre parcel north of the Site by the Township, along with oversight by EPA, MDEQ and the FWCC should reliably restrict usage of the shallow aquifer on-Site and on the 80-acre property. However, there is no formal control over ground-water usage on adjacent properties. This is primarily a concern north and west of the 80-acres where VOCs exceeding action levels have been detected and a considerable number of residences have been constructed since the time of the RI, and further development is likely. Development east of the Site appears to be less likely, but still could occur.

- *Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?*

The exposure and risk assumptions and conclusions in the ROD documents are generally still valid. Relative to risks to aquatic life, EPA and MDEQ have adequately documented that the Site has not had an identifiable impact on Butternut Creek or the wetlands east of the Site. In addition, application of the aquatic protection ground-water action levels from the SOW will provide protection to aquatic life from venting of contaminated shallow ground-water to the lake north of the Site, or to the wetlands east of the Site.

- *Question C: Has any other information come to light that could call into question the protectiveness of the remedy?*

EPA, MDEQ and the FWCC appear to have done as much as reasonably possible to identify all disposal areas on the Site property. Although there are no present plans for more extensive development of the Site property outside of the landfill, available sampling results are generally favorable for more extensive development. However, arsenic exceeded the PRG and the range of background concentrations in some soil samples from the Site.

Even though the east plume has been monitored in compliance with the Consent Decree SOW, PBBs were never analyzed apparently because PBBs were not considered to be a threat to ground-water. This assumption should be revisited because the landfill is known to be a major source of PBBs. The east plume monitoring has been reduced substantially since 1999, but review of the most recent monitoring data indicates that it may be premature to substantially reduce monitoring of the east plume.

The parties have made a lot of progress in the north plume investigation, although the process has been prolonged. A number of VOCs have been detected exceeding action levels outside of the boundary of the 80-acre property north of the Site. In addition, arsenic, iron, a few pesticides and naphthalene have been detected exceeding action levels on the 80-acres near the landfill. The FWCC has been very cooperative in the investigation process. However to date, the north plume contamination is still not adequately characterized to evaluation remedial alternatives. During this continuing investigation, nearby residential wells have been sampled to assure that their drinking water is safe. The FWCC has stated that they will submit an evaluation of alternatives to address the north plume within 30 days after receipt of the validated data from the most recent phase of investigation. Metals, SVOCs, pesticide/PCBs and PBBs have not yet been adequately characterized in the north plume.

The drinking water protection action levels are protective if the shallow sand and deep sand and gravel aquifers are not developed to the north or east of the Site and of the 80-acres north of the Site. Presently there are no formal restrictions on such usage. If such usage occurs, compliance with the drinking water protection ground-water action levels from the SOW may not provide sufficient protection to off-Site ground-water users.

Ambient air emissions, and soil gas migration are very unlikely to be a problem at this Site, but this has not been verified by field measurements.

Technical Assessment Summary

The last Five-Year Review was completed on March 2, 1997. The 1997 Review only included a protectiveness statement regarding the lagoon remedial action. It certified that

the lagoon remedy remained protective of human health and the environment. It concluded that all contaminated soils and sludges had been removed from the lagoon area. This finding has not changed and is reiterated in this Five-Year Review.

The 1997 Review recommended that the landfill cap and fence construction and ground-water investigation of the north plume proceed on its then existing schedule. Both the landfill cap and fencing are completed and functioning as designed.

VIII. Issues

- The 1997 Review stated that a determination should be made regarding the need for ground-water remediation to address the north plume contamination. Although additional investigations have occurred, the north plume still has not been adequately characterized to evaluate remedial options, or to design a remedy.

- It is unclear whether the PBB detection limit is adequate to evaluate the Site risks.

- It is unclear whether landfill gases present a heath risk at the Site.

IX. Recommendations and Follow-up Actions

- As is planned, the on-going north plume investigation needs to be completed to delineate and characterize the north plume. This investigation is being conducted by the FWCC with oversight by EPA and MDEQ. MDEQ is also conducting an investigation to detect contamination venting to the lake.

  As is planned, options for remediation of the north plume need to be evaluated, and implemented. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA.

  As is planned, annual sampling of residential wells near the north plume area should be continued. More frequent sampling should be implemented for any nearby residential well that is screened in the shallow sand or deep sand and gravel aquifers. This is expected to be conducted by the FWCC with oversight by EPA.

  As is planned, a new long-term monitoring plan, including monitoring the north plume, the east plume and near the landfill, should be developed after delineation of the north plume is completed. Continued monitoring of the east plume will still be needed. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA. Including in the monitoring and analysis of total metals instead of filtered metals should be considered.

- US EPA will evaluate whether the PBB detection limit is adequate to evaluate the Site

risks.

- US EPA will evaluate whether landfill gases present a heath risk at the Site.

- The existing maintenance program for the landfill cap and fence should be continued. Periodic inspection and maintenance of the fence around the Site should be added to this effort. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA.

- Either the ground-water action levels in the SOW should be updated to be protective for exposure to multiple carcinogenic contaminants and to keep exposure rates for non-carcinogens below their reference doses, or usage restrictions should be imposed on the shallow sand and deep sand and gravel aquifers north of the Site, and on use of the shallow sand aquifer east of the Site. EPA will attempt to gain cooperation from the FWCC and/or the State and local government to address these recommendations.

- The need to conduct air sampling to characterize landfill gas emissions should be evaluated, and the air sampling conducted if necessary as required in the SOW. Pursuant to the Consent Decree, this action must be conducted by the FWCC with oversight by EPA.

- The need to conduct soil gas monitoring should be evaluated, and the soil gas monitoring conducted if necessary. Pursuant to the Consent Decree, if necessary, this action must be conducted by the FWCC with oversight by EPA.

X. Statement on Protectiveness

The remedy is protective in the short-term because there is no evidence that there is current exposure. In order for the remedy to remain protective in the long term, the following actions need to be implemented:

- Completion of the on-going north plume investigation to delineate and characterize the north plume;
- Evaluation alternatives and implementation of remediation of the north plume;
- until the plume is delineated or controlled, continue annual sampling of residential wells near the north plume area, and more frequent sampling of any nearby residential well that is screened in the shallow sand or deep sand and gravel aquifers;
- Evaluate the need to monitor for PBBs in ground-water, and add PBBs to the monitoring program if necessary;
- Either update the ground-water action levels in the SOW to be protective for exposure to multiple contaminants and non-carcinogens, or impose usage restrictions on the shallow sand and deep sand and gravel aquifers north of the

Site, and on the shallow sand aquifer east of the Site;
- Evaluate the need to conduct air sampling to characterize landfill gas emissions, and implement the air sampling if necessary; and
- Evaluate the need to conduct soil gas monitoring, and implement the soil gas monitoring if necessary to assure that landfill gas is not migrating into off-Site structures.

EPA is taking the steps outlined in Section VII, Recommended Actions, to make the remedy protective.

XI. Next Five-Year Review

The next five-year review is scheduled to be conducted by September 2007.

LIST OF ACRONYMS AND ABBREVIATIONS

CRA:	Conestoga-Rovers & Associates, a technical consultant for the FWCC
Donahue:	Donahue & Associates, Inc., a contractor for the U.S. Army Corps of Engineers
EPA:	The United States Environmental Protection Agency
ESD:	Explanation of Significant Differences (EPA documents to approve significant but not major changes to the ROD)
FWCC:	Forest Waste Coordinating Committee (group of settling parties who are implementing the remedial actions pursuant to a Consent Decree with EPA)
GCHD:	Genesee County Health Department
McLaren Hart:	McLaren Hart Environmental Engineering Corporation, a technical consultant for the FWCC
MCL:	Safe Drinking Water Act Maximum Contaminant Level
MDEQ:	The Michigan Department of Environmental Quality
PBBs:	Polybrominated biphenyls
PCBs:	Polychlorinated biphenyls
PRGs:	Region 9 Preliminary Remediation Goals. These are risk-based screening levels.
RI/FS:	Remedial Investigation/Feasibility Study
ROD:	EPA's Decision Document Called a Record of Decision
SOW:	Consent Decree Scope of Work
SVOCs:	Semivolatile organic compounds
TCDD:	tetrachlorodibenzodioxin
ug/l:	Concentration of a Contaminant in Water in Micrograms of Contaminant Per Liter of Water (or parts per billion)
VOCs:	Volatile Organic Compounds

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TABLE 1
COMPARISON OF MAXIMUM PARAMETER CONCENTRATIONS WITH DRINKING WATER ACTION LEVELS AND REGION 9 TAP WATER PRGs FOR MONITORING WELLS WITHIN AND OUTSIDE OF 900 FEET FROM THE LANDFILL USING DATA FROM THE NORTH PLUME INVESTIGATION 1999 - 2002
UNITS IN UG/L (ND = NOT DETECTED, NA = NOT ANALYZED)

PARAMETER	MAXIMUM WITHIN 900 FT[7]	MAXIMUM BEYOND 900 FT [8]	DRINKING WATER ACTION LEVEL	TAP WATER PRG
ACETONE	1500	ND	3500	610
BENZENE	180	ND	5	0.65
BUTANONE (2-)	830	ND	1750	7,300
CARBON TETRACHLORIDE	380	ND	5	0.71
CHLOROBENZENE	99	ND	100	110
CHLOROETHANE	6100	170	NONE	4.6
DICHLOROETHANE (1,1)	3800	900	4200	810
DICHLOROETHANE (1,2)	95	6	5	0.21
DICHLOROETHYLEN E (1,1)	260	21	7	0.046
DICHLOROETHYLENE (1,2-TOTAL CIS AND TRANS)	1100	2600	70	61
DICHLOROPROPANE (1,2-)	41	ND	5	0.16
ETHYLBENZENE	1100	ND	700	1,300
METHYLENE CHLORIDE	300	13	4.7	4.3
METHYLPENTANONE (4-, 2-)	4800	ND	1750	NONE
TOLUENE	8000	ND	2000	720
TRICHLOROETHANE (1,1,1-)	23	100	200	540
TRICHLOROETHYLENE	26	ND	5	1.6
TRIMETHYLBENZENE (1,2,4)	100	ND	NONE	12
VINYL CHLORIDE	1100	560	2	0.041

[7] These include sample results for 1999 – 2001 in monitoring wells MW95-1S, PZ96-1, PZ96-5, PZ96-11, MW01-25S, MW99-3S, MW99-1S, BH00-05, MW99-2S, PZ97-9, MW01-26S.

[8] These include sample results from 1999 – 2001 in monitoring wells PZ97-10, MW99-5S, PZ99-1, MW99-10S, MW01-24S, BH02-07S, MW02-31S, and BH02-33D.

XYLENES (TOTAL)	4900	ND	10000	1,400
ARSENIC	56.4	NA	50	0.045
CYANIDE	12.4	NA	700	6.2
IRON	12,600	NA	NONE	11,000
HEXACHLOROBENZENE	0.05	NA	28	0.042
4-METHYLPHENOL	690	NA	1,750	180
NAPHTHALENE	60	NA	14,000	6.2

TABLE 2
COMPARISON OF MAXIMUM DETECTIONS IN NORTH PLUME NEAR THE LAKE TO ACTION LEVELS FOR WETLAND PROTECTION AND WITH CURRENT BENCHMARKS FOR VOCs DETECTED IN Ground-water NEAR THE LAKE DURING THE NORTH PLUME INVESTIGATION (IN UG/L)

PARAMETER	MAXIMUM DETECTION	WETLAND ACTION LEVEL	CURRENT MOST-STRINGENT BENCH MARK[9]
CHLORETHANE	170	NONE	230,000
1,1-DICHLOROETHANE	900	NONE	1,590
1,2-DICHLOROETHANE	6	560	1,260
1,1-DICHLORETHYLENE	900	2.6	303
1,2-DICHLOROETHYLENE (CIS AND/OR TRANS)	2600	300	310
1,1,1-TRICHLOROETHANE	100	117	251
VINYL CHLORIDE	560	NONE	930

[9] This is the most stringent screening benchmark for aquatic affects identified in a memorandum dated June 4, 2001 by David Brauner of EPA, Region 5.

TABLE 3
COMPARISON OF MAXIMUM PARAMETER CONCENTRATIONS DETECTED IN EAST PLUME AREA IN 1999 – 2001
WITH DRINKING WATER ACTION LEVELS AND REGION 9 TAP WATER PRGs

UNITS IN UG/L (ND = NOT DETECTED)

PARAMETER	MAX. DETECT	DRINKING WATER ACTION LEVEL	TAP WATER PRG
DICHLOROETHANE (1,2)	17	5	0.21
DICHLOROPROPANE (1,2-)	2	5	0.16
TRICHLOROETHYLENE	5	5	1.6
VINYL CHLORIDE	3	2	0.041
BIS(2-ETHYLHEXYL)PHTHALATE	11	6	4.8
ARSENIC	27.2	50	0.045
IRON	6,320	NONE	11,000

Summary of Michigan Department of Environmental Quality (MDEQ) Review Comments on Draft Five Year Review Document Not Addressed Specifically in the Document

- MDEQ requests the opportunity to perform additional review of the Final Five Year Review document and to provide comments that will be attached to the final report.
- MDEQ disagrees with the amount of discussion in the Five Year Review on the earlier remedial action and the north plume.
- MDEQ recommends that a source control evaluation be conducted.
- MDEQ recommends that the 1988 ROD be amended to incorporate Michigan Part 201 criteria.
- MDEQ recommends that additional sampling be required in the Recommendations Section.
- MDEQ points out the lack of community involvement in the document.
- MDEQ has some unspecified editorial concerns.
- MDEQ is concerned that the Risk Assessment section was not evaluated by a MDEQ toxicologist because of timing issues.

LIST OF ATTACHMENTS

Attachment 1: Color Site Location Map

Attachment 2: Figure 3-1 from the RI, Soil Sampling Locations

Attachment 3: Color Terrain Map

Attachment 4: Figure 3-6 from the RI, Residential Well Sampling Locations and Well Screen Intervals

Attachment 5: Figure 1 by CRA, Residential Well Locations, March 21, 2002

Attachment 6: Figure 4-3 from the RI, Generalized Geologic Cross Section

Attachment 7: Figure 4-28 from the RI, Inorganic Constituents Above Background Concentrations Phase I and III Surface Water Samples

Attachment 8: Figure 4-29 from the RI, Organic Compounds in Phase I and III Surface Water Samples

Attachment 9: Figure 4-30 from the RI, Inorganic Constituents Above Background Concentrations Phase I and IIII Sediment Samples

Attachment 10: Figure 4-31 from the RI, Organic Compounds in Phase I and III Sediment Samples

Attachment 11: Figure 4-32 from the RI, Inorganic Compounds above Background Concentrations in Phase II Mammal Samples

Attachment 12: Figures 4-33 from the RI, Organic Compounds in Phase II Mammal Samples

Attachment 13: Figure 1-4 from the RI, Groundwater Elevations in the Shallow Aquifer

Attachment 14: ground-water action levels from Consent Decree SOW, pages 1-22

Attachment 15: Figure 2 by McLaren Hart 6/20/95, Monitoring Well Location Plan

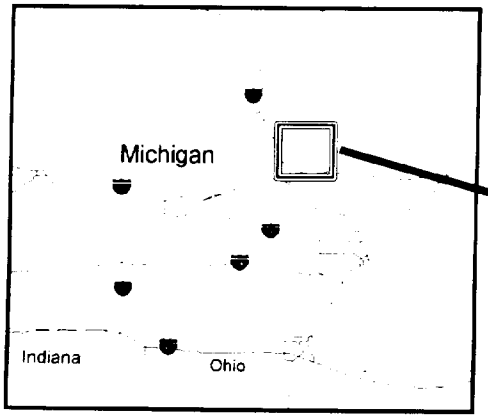
Attachment 16: Figure 1 by CRA, August 27, 2002, Proposed Additional VAS Locations – Shallow Aquifer

Attachment 17: Figure 1 from the Annual Report for Groundwater Operable Unit Remedial Action, CH2M-Hill, Inc., October 3, 1991

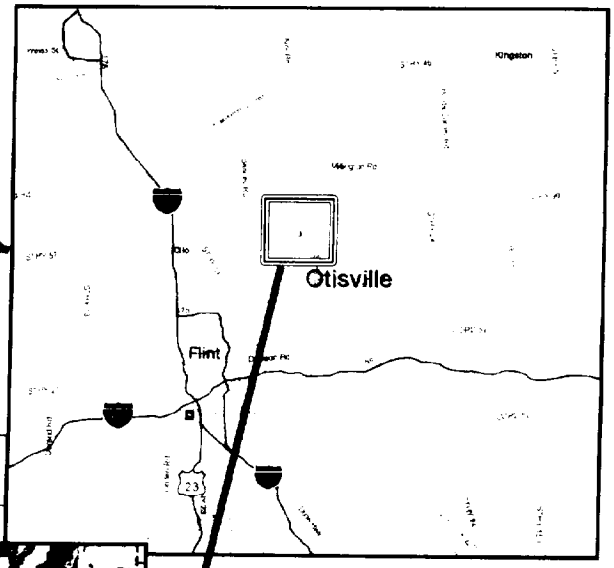
Attachment 18: Figure 2 by CRA, June 21, 2002, Proposed Scope of Work Deep Aquifer

Forest Waste Products Superfund Site
Genesee County, Michigan

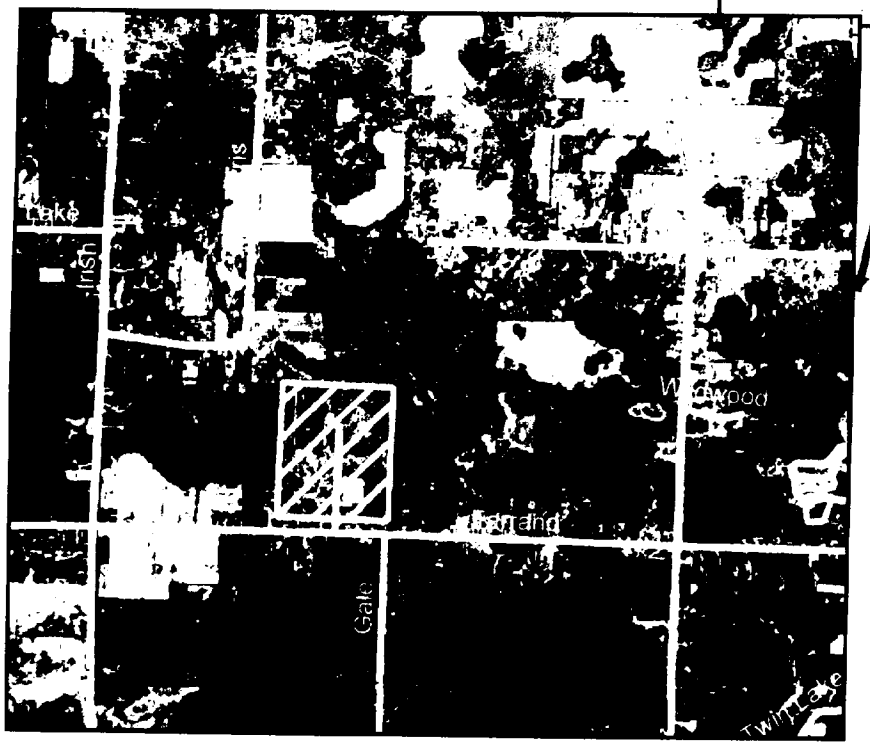
1) State



2) City of Otisville



3) Forest Waste Products Superfund Site

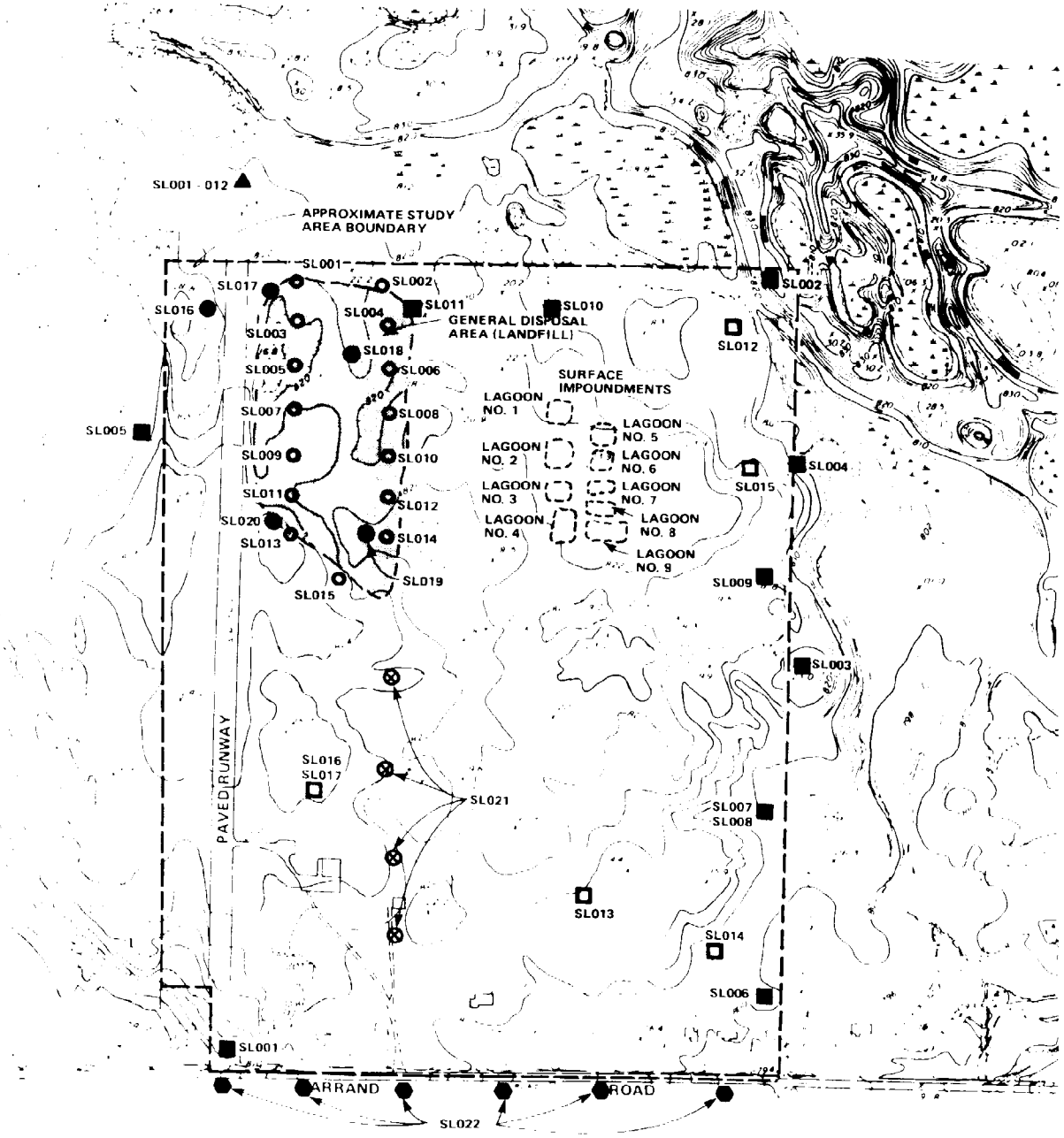


N

Plot created by Dave Wilson U.S. EPA Region 5 on 9/12/2002
Color Infra_Red Image Date 4/25/2000

Figure 1

SEPA



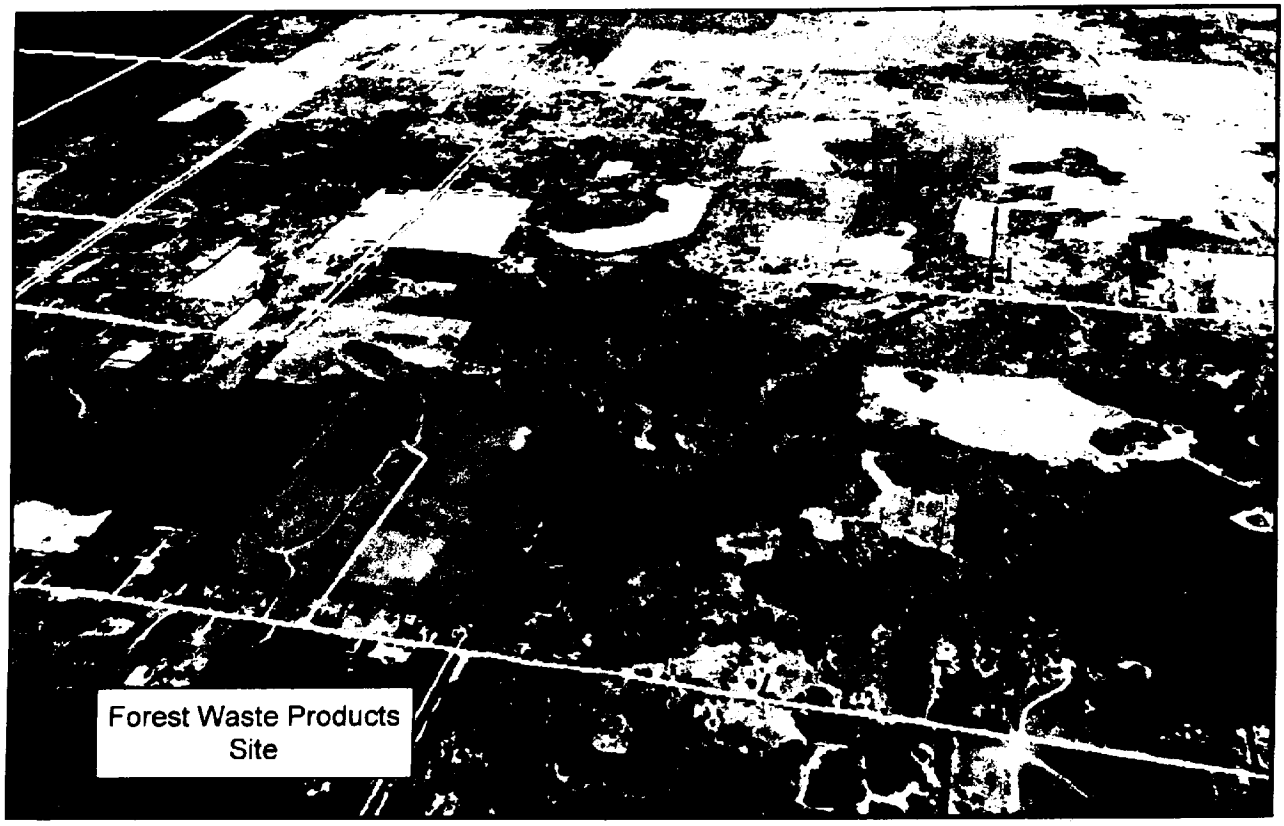
LEGEND

- COMPOSITE SOIL SAMPLE - PHASE I
- COMPOSITE SOIL SAMPLE - PHASE II
- DISCRETE ACCESS ROAD SOIL SAMPLE - PHASE I*
- GRAB SOIL SAMPLE - PHASE I
- GRAB SOIL SAMPLE - PHASE II
- SUBSURFACE SOIL SAMPLE - PHASE III, EXCEPT LAGOON
- DISCRETE FARRAND ROAD SOIL SAMPLE - PHASE I*

*(Discrete samples were composited for analysis).

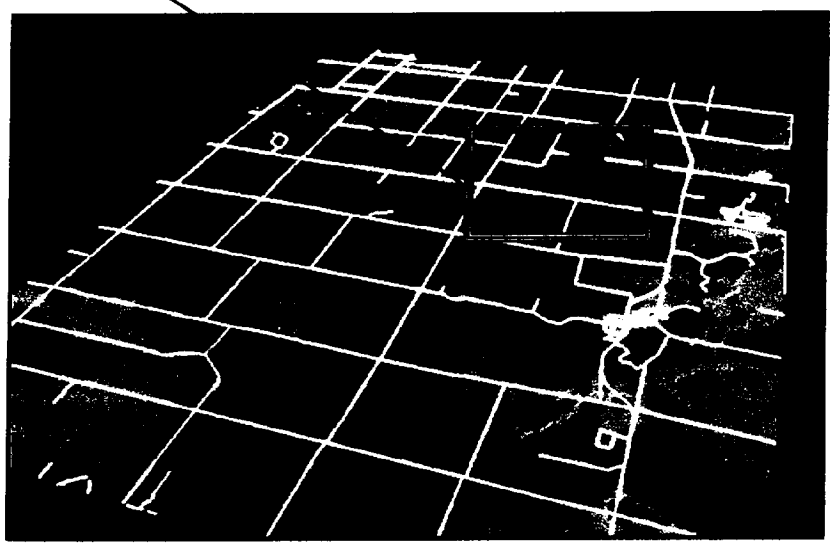
FIGURE 3-1
SOIL SAMPLING LOCATIONS
FOREST WASTE RI

Forest Waste Products Superfund Site
3D Surface Terrain Model



Elevation Feet

- 262 - 268
- 257 - 262
- 252 - 257
- 247 - 252
- 242 - 247
- 237 - 242
- 232 - 237
- 227 - 232
- 222 - 227



Plot created by David Wilson U.S. EPA Region 5 on 9/15/2002
Color Infra-Red Image Date 4/25/2000

EPA [illegible] Region [illegible]

Figure 2

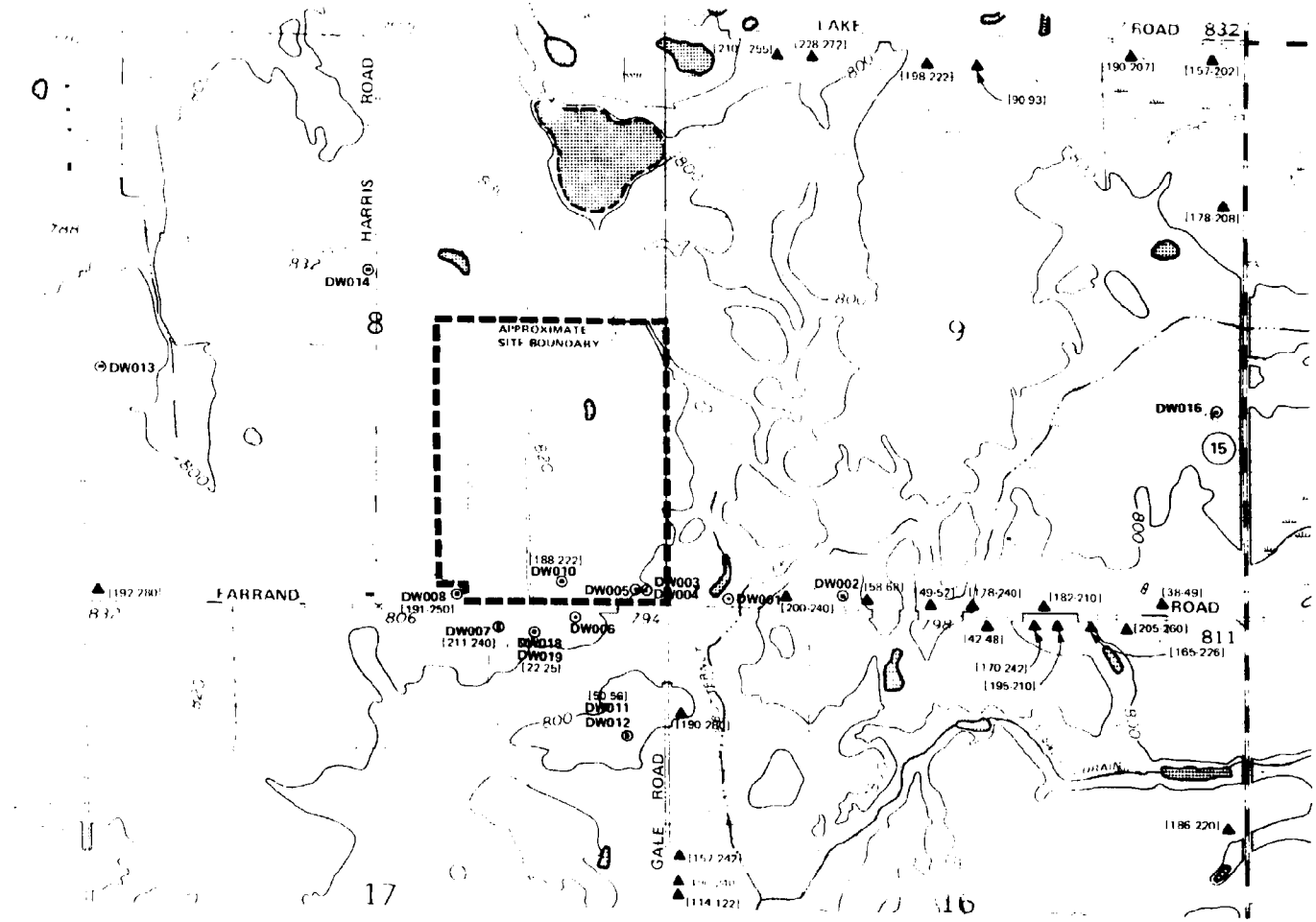
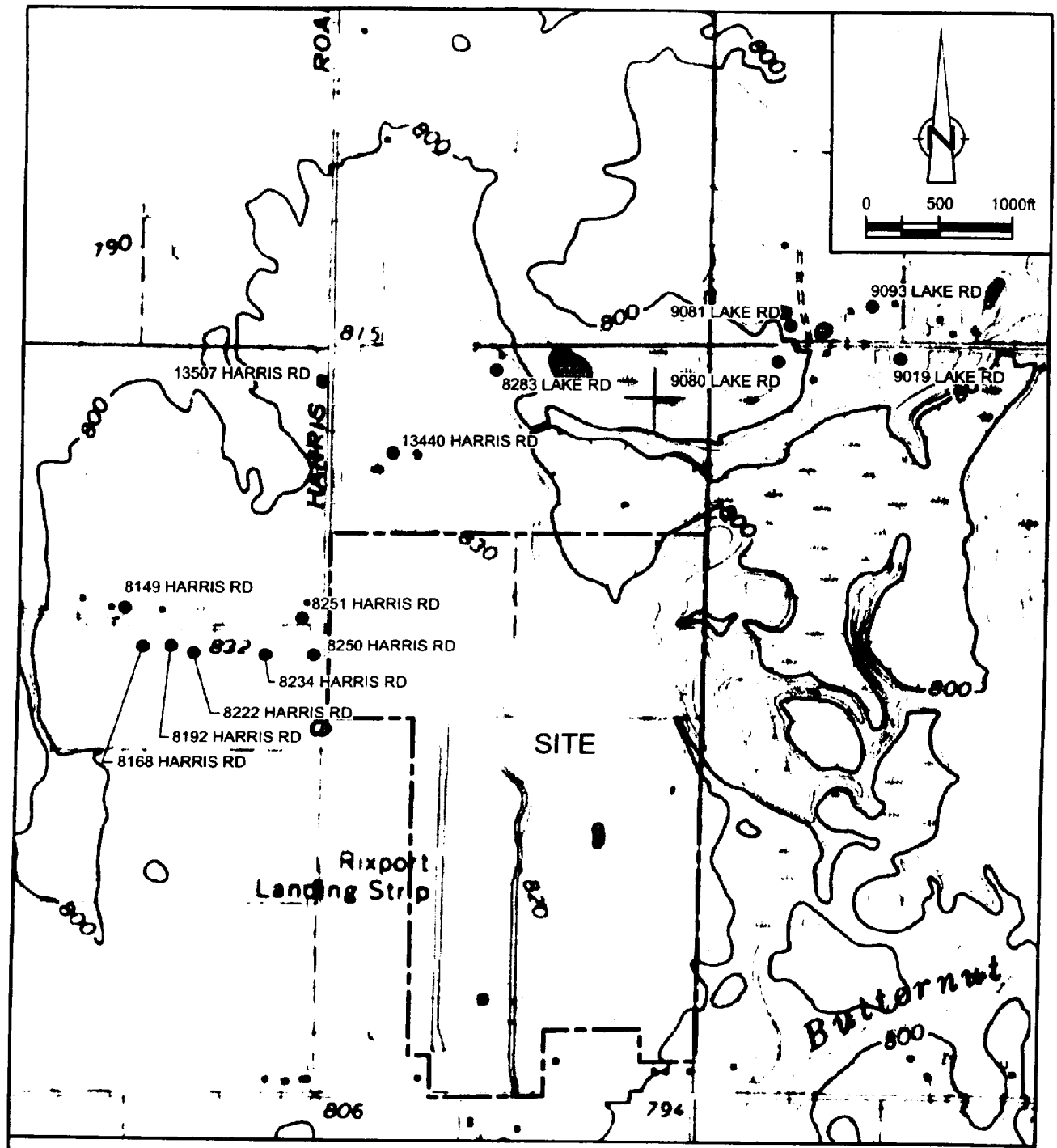


FIGURE 3-6
RESIDENTIAL WELL SAMPLING LOCATIONS AND WELL SCREEN INTERVALS FOR AREA WELLS
FOREST WASTE RI



BACKGROUND SOURCE USGS QUADRANGLE MAP, OTISVILLE, MICHIGAN

NOTE ALL WELLS AND BOREHOLE ARE APPROXIMATE POSITIONS ONLY. PLOTTED OFF MUNICIPAL WELL LOGS

LEGEND

- RESIDENTIAL WELL (APPROXIMATE LOCATION)
- APPROXIMATE SITE BOUNDARY

figure 1

RESIDENTIAL WELL LOCATIONS
FOREST WASTE DISPOSAL SITE
Otisville, Michigan

12210-40(BOIC048)GN-WA001 MAR 21/2002

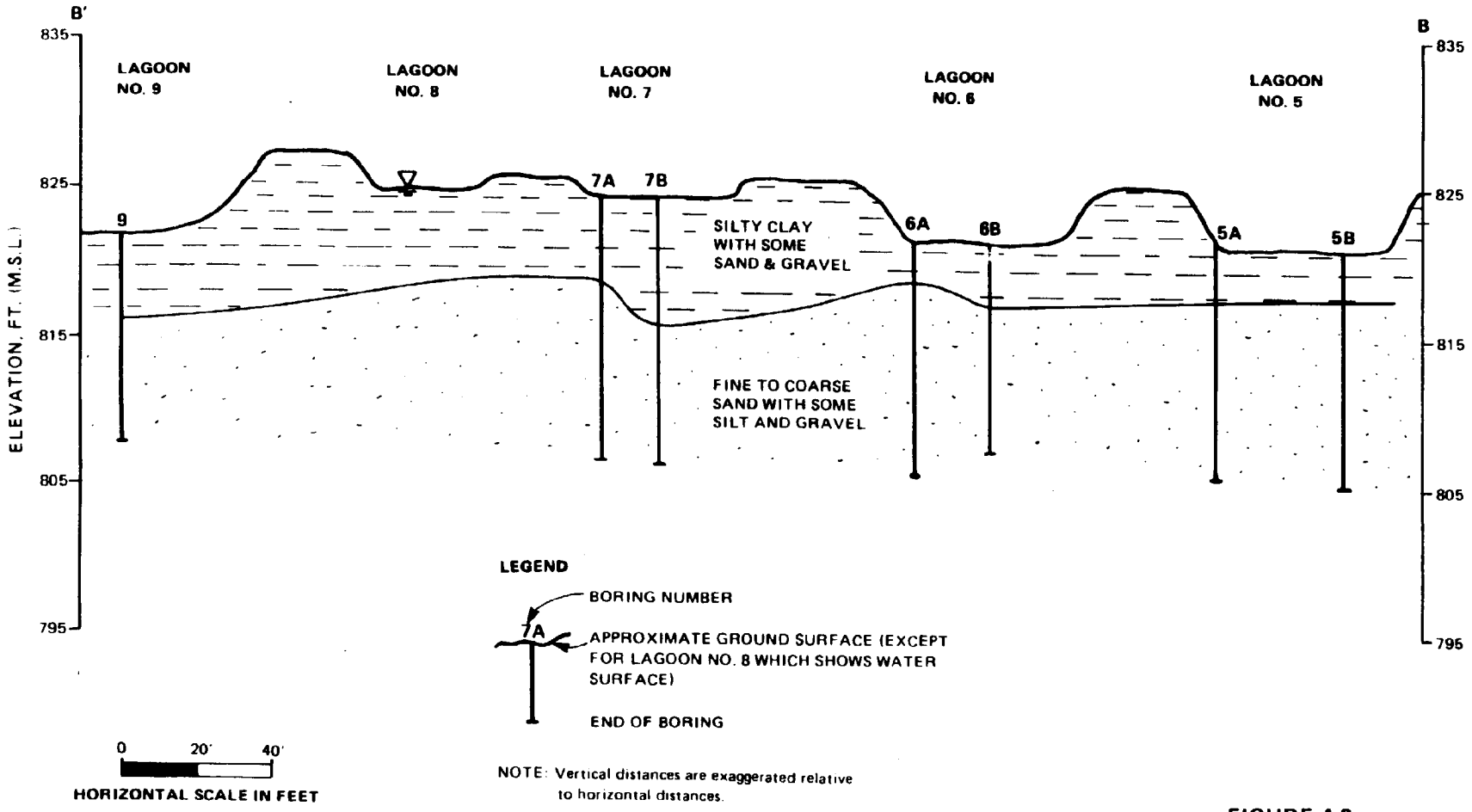
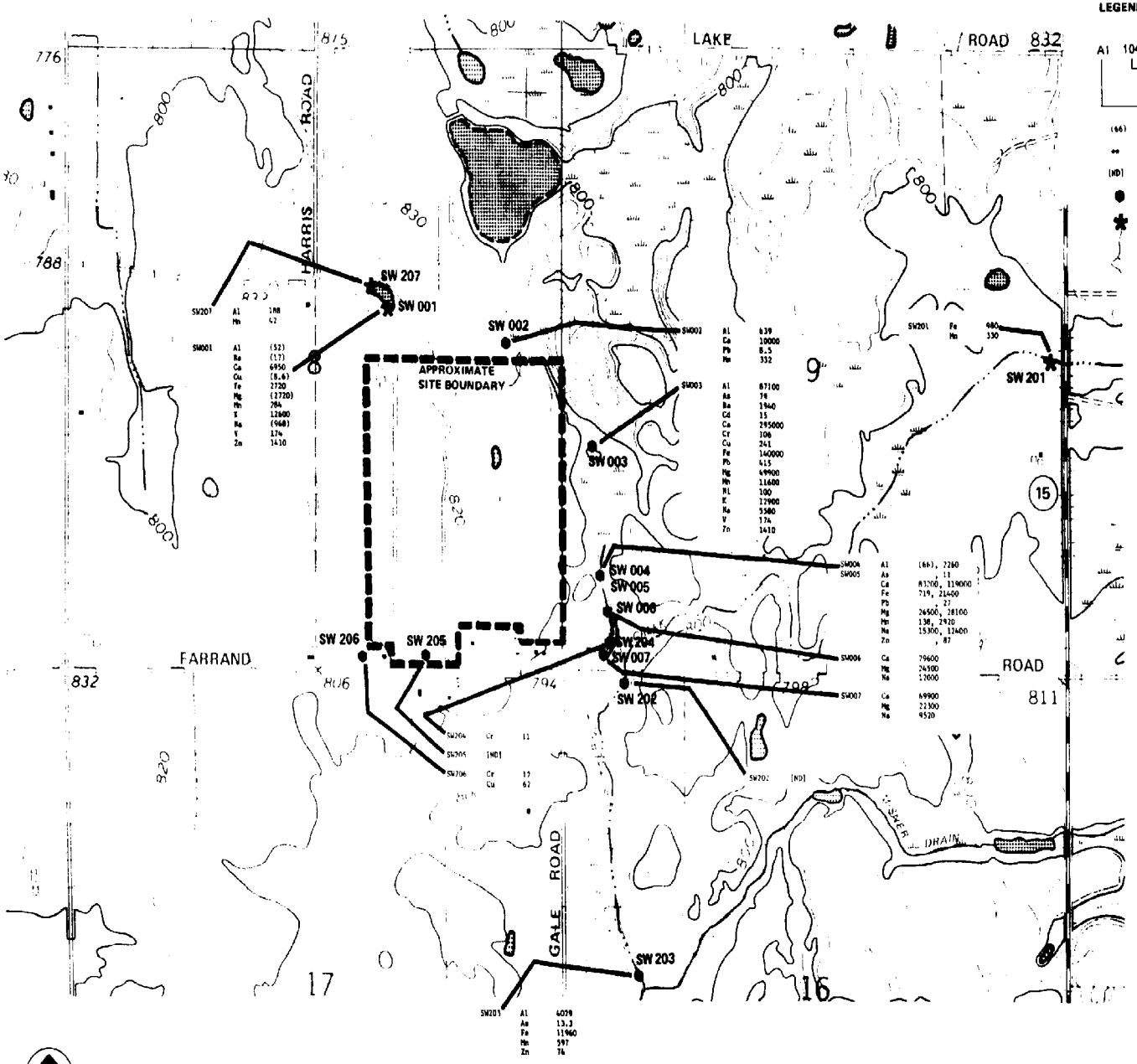


FIGURE 4-3
GENERALIZED GEOLOGIC CROSS SECTION B - B'
FOREST WASTE RI



LEGEND

- Al 104, 105 — CONCENTRATION IN UG/L REPORTED FOR DUPLICATE SAMPLE (WHEN TAKEN)
- Al 104, 105 — CONCENTRATION IN UG/L REPORTED FOR SAMPLE
- Al — CONSTITUENT
- (66) ESTIMATED VALUE
- ** DATA IS QUALIFIED (REFER TO DATA
- IND) CONSTITUENT NOT DETECTED
- ● SURFACE WATER SAMPLES
- ✱ BACKGROUND SURFACE WATER SAMPLES

INORGANIC CONSTITUENT KEY

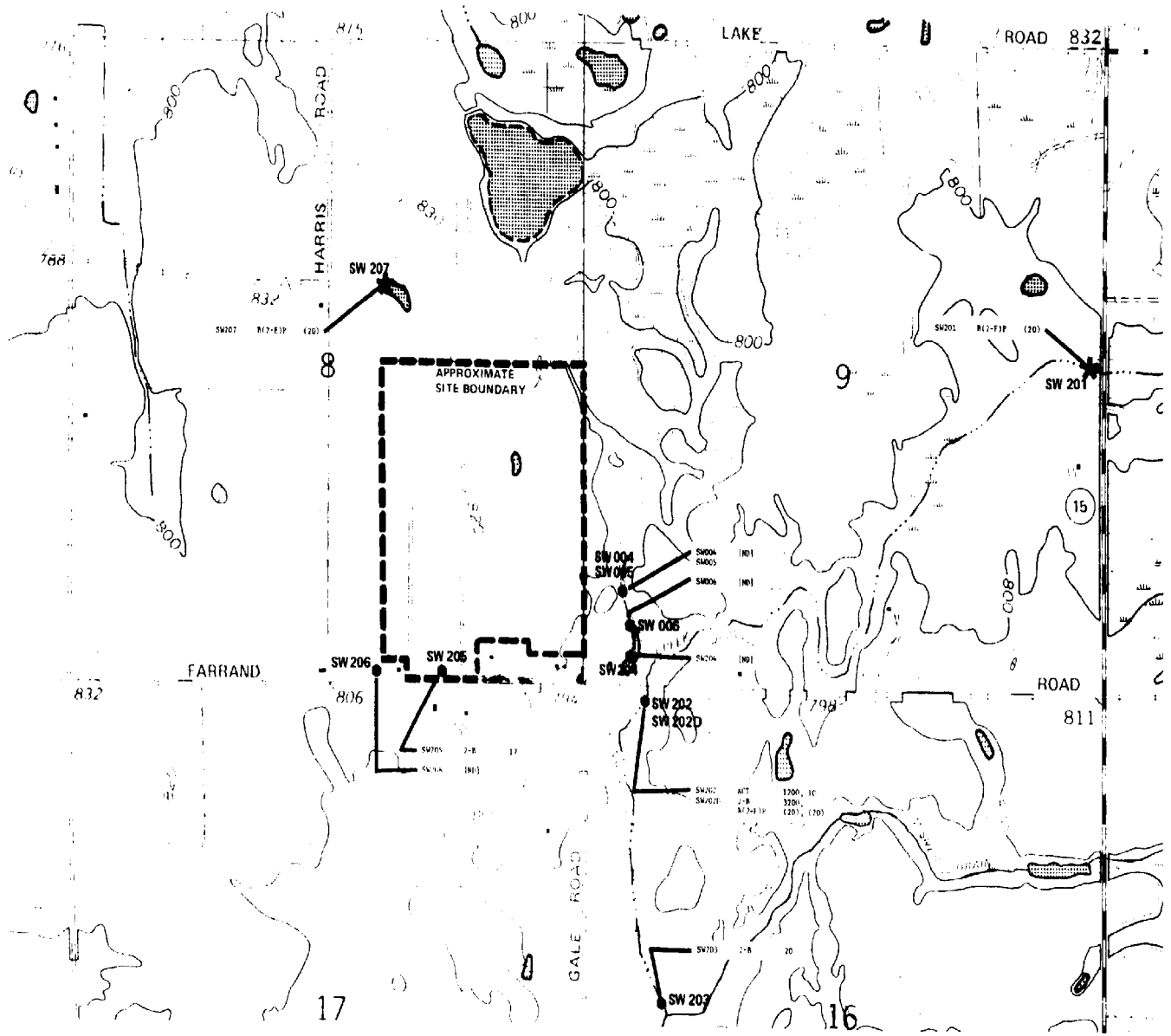
Abbreviation	Name	Comparison Background Concentrations (ug/l)
Al	Aluminum	L.T.D.L.-200
As	Arsenic	L.T.D.L.-10
Ba	Barium	L.T.D.L.-200
Be	Beryllium	L.T.D.L.-5
Cd	Cadmium	L.T.D.L.-5
Ca	Calcium	L.T.D.L.-6,950
Cr	Chromium	L.T.D.L.-10
Co	Cobalt	L.T.D.L.-50
Cu	Copper	L.T.D.L.-25
Fe	Iron	L.T.D.L.-2,720
Pb	Lead	L.T.D.L.-5
Mg	Magnesium	L.T.D.L.-5,000
Mn	Manganese	42-330
Ni	Nickel	L.T.D.L.-40
K	Potassium	L.T.D.L.-12,600
Na	Sodium	L.T.D.L.-5,000
V	Vanadium	L.T.D.L.-50
Zn	Zinc	L.T.D.L.-20

NOTE: ALL CONCENTRATIONS ARE REPORTED AS TOTAL CONCENTRATIONS FROM UNFILTERED SAMPLES.

N

0 1000
SCALE IN FEET

FIGURE 4-28
INORGANIC CONSTITUENTS ABOVE BACKGROUND CONCENTRATIONS IN PHASE I AND III SURFACE WATER SAMPLES
FOREST WASTE RI



LEGEND

ACN 104, 105 — CONCENTRATION IN UG/L REPORTED FOR DUPLICATE SAMPLE (WHEN TAKEN); CONCENTRATION IN UG/L REPORTED FOR SAMPLE; CONSTITUENT

(66) ESTIMATED VALUE

(ND) CONSTITUENT NOT DETECTED

● SURFACE WATER SAMPLES PHASE I

✱ BACKGROUND SURFACE WATER SAMPLES

ORGANIC COMPOUND KEY

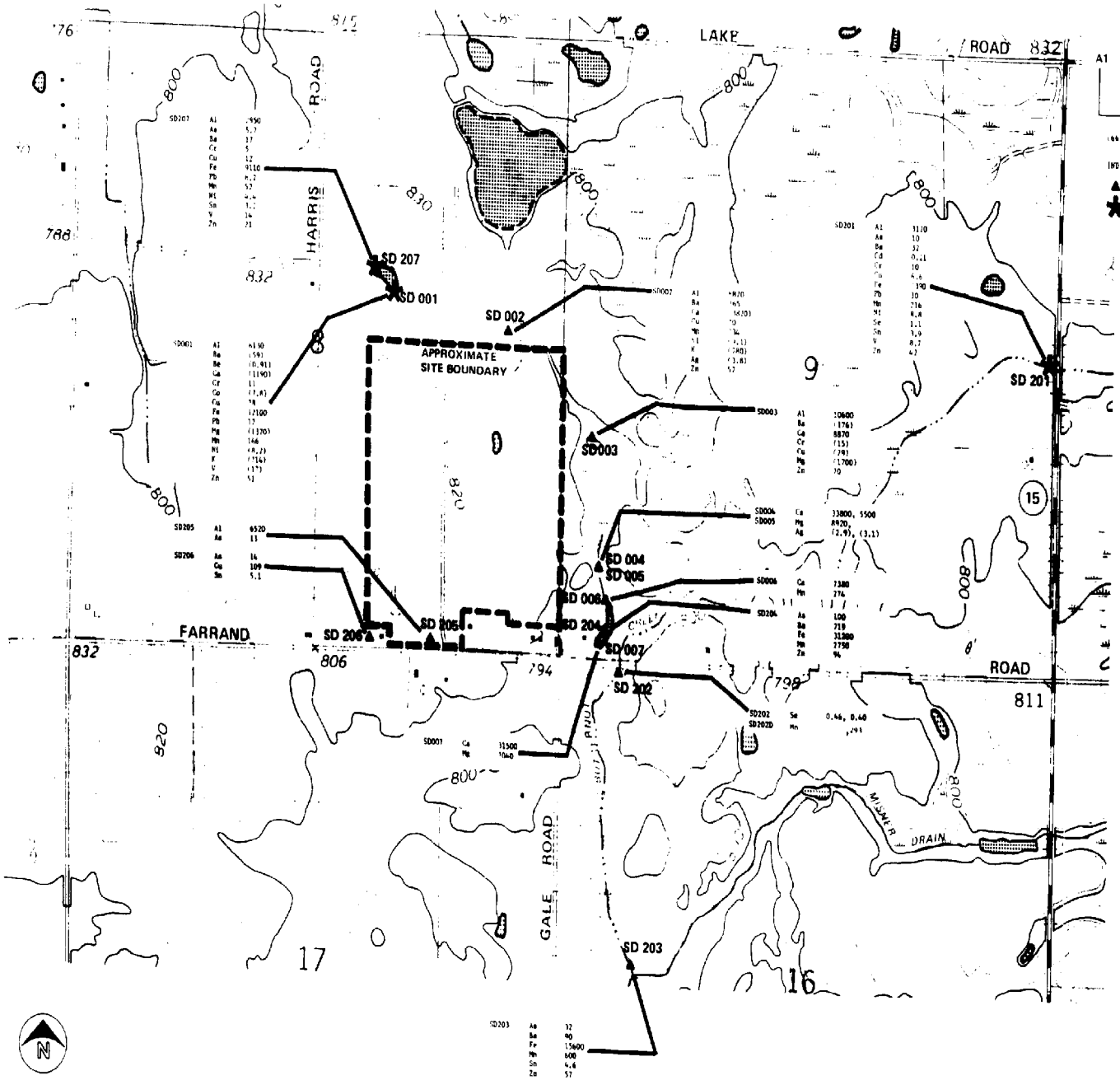
Abbreviation	Compound Name
ACT	acetone
B(2-E)P	bis(2-ethylhexyl)phthalate
2-B	2-butanone

N

0 1000

SCALE IN FEET

FIGURE 4-29
ORGANIC COMPOUNDS IN PHASE I AND III SURFACE WATER SAMPLES
FOREST WASTE RI



A1 104, 105
- CONCENTRATION IN mg/kg REPORTED FOR DUPLICATE SAMPLE (WHEN TAKEN)
- CONCENTRATION IN mg/kg REPORTED FOR SAMPLE
- CONSTITUENT

(66) ESTIMATED VALUE

IND CONSTITUENT NOT DETECTED

▲ SURFACE WATER SAMPLES

✱ COMPARISON BACKGROUND SURFACE WATER SAMPLES

INORGANIC CONSTITUENT KEY

Abbreviation	Name	Comparison Background Concentrations (mg/kg)
Al	Aluminum	2,950-6,130
Sb	Antimony	L.T.D.L.(20)*
As	Arsenic	L.T.D.L.-10
Ba	Barium	17-59
Be	Beryllium	L.T.D.L.-0.91
Cd	Cadmium	L.T.D.L.(3.9)*
Ca	Calcium	L.T.D.L.-1,190
Cr	Chromium	5-11
Co	Cobalt	L.T.D.L.(7.8)*
Cu	Copper	6.6-26
Fe	Iron	7,390-12,100
Pb	Lead	6.2-30
CN	Cyanide	L.T.D.L.-0.78
Mg	Magnesium	L.T.D.L.-1,370
Mn	Manganese	52-216
Ni	Nickel	4.4-8.8
K	Potassium	L.T.D.L.-714
Se	Selenium	L.T.D.L.(3.9)*
Ag	Silver	L.T.D.L.(2.3)*
Sn	Tin	L.T.D.L.-3.9
V	Vanadium	8.7-17
Zn	Zinc	21-51

*Constituent was not detected in the background samples. Value shown is the CLP required detection limit.

FIGURE 4-30
INORGANIC CONSTITUENTS ABOVE BACKGROUND CONCENTRATIONS IN PHASE I AND III SEDIMENT SAMPLES
FOREST WASTE RI

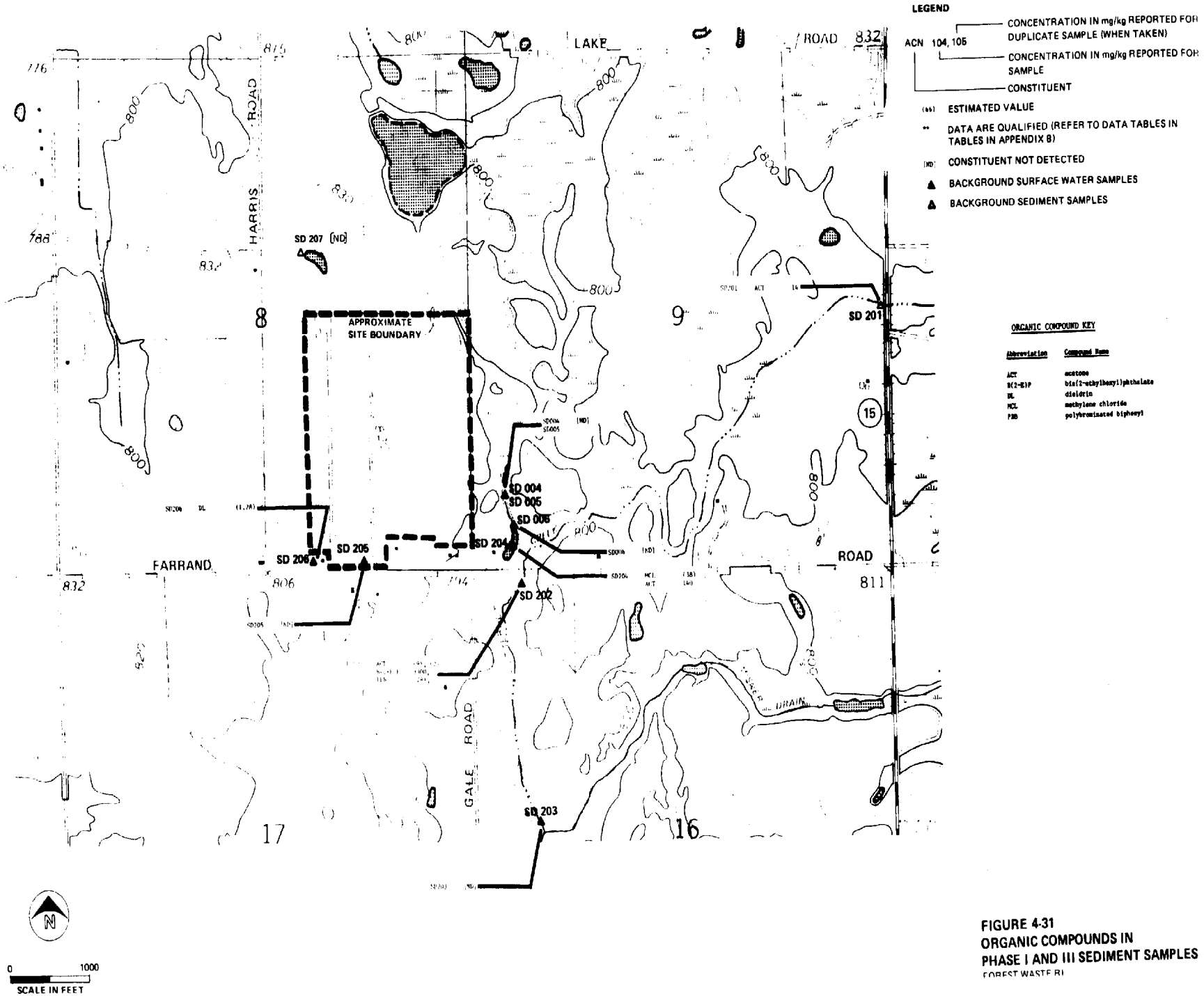


FIGURE 4-31
ORGANIC COMPOUNDS IN
PHASE I AND III SEDIMENT SAMPLES
FOREST WASTE RI

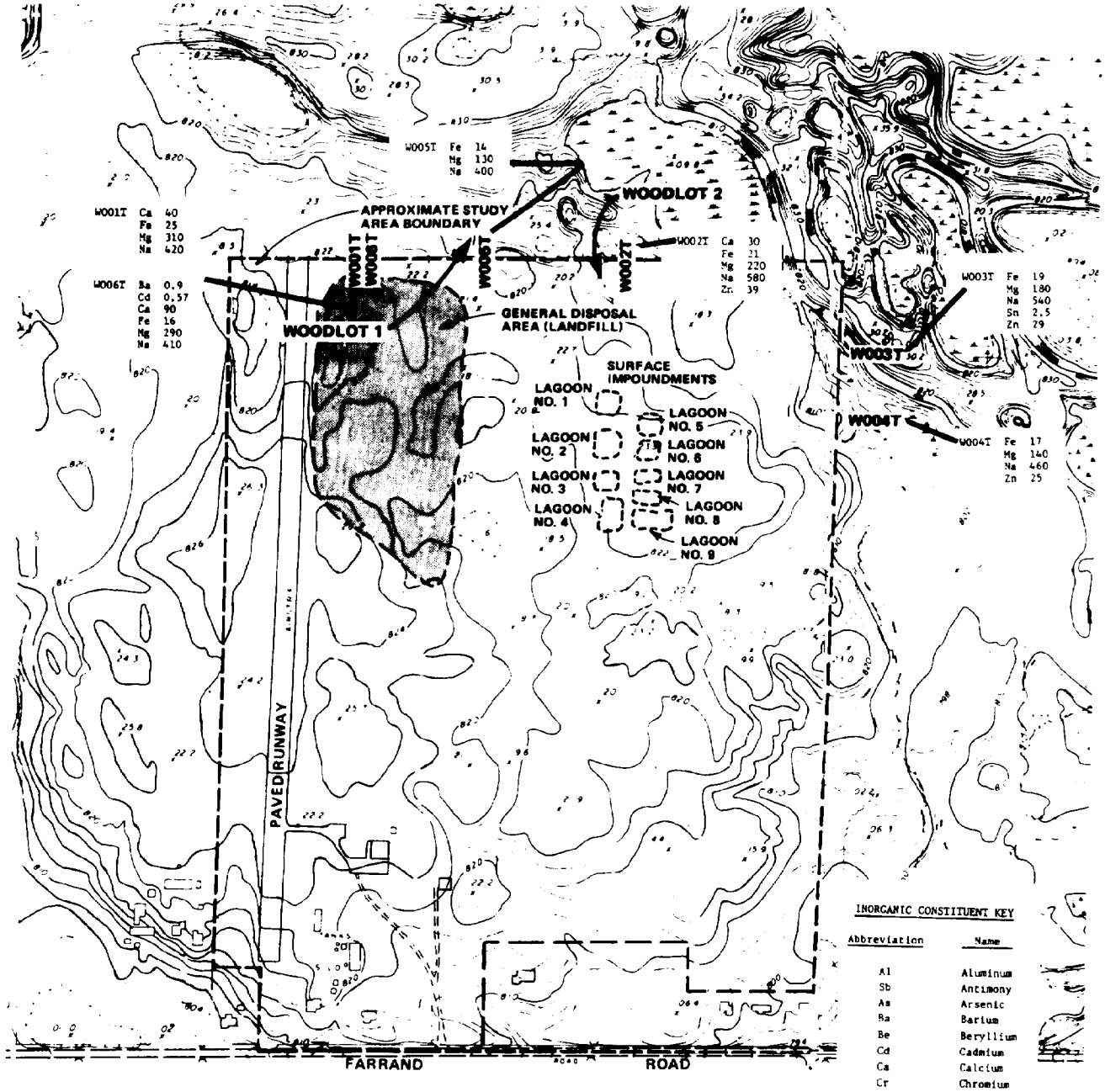
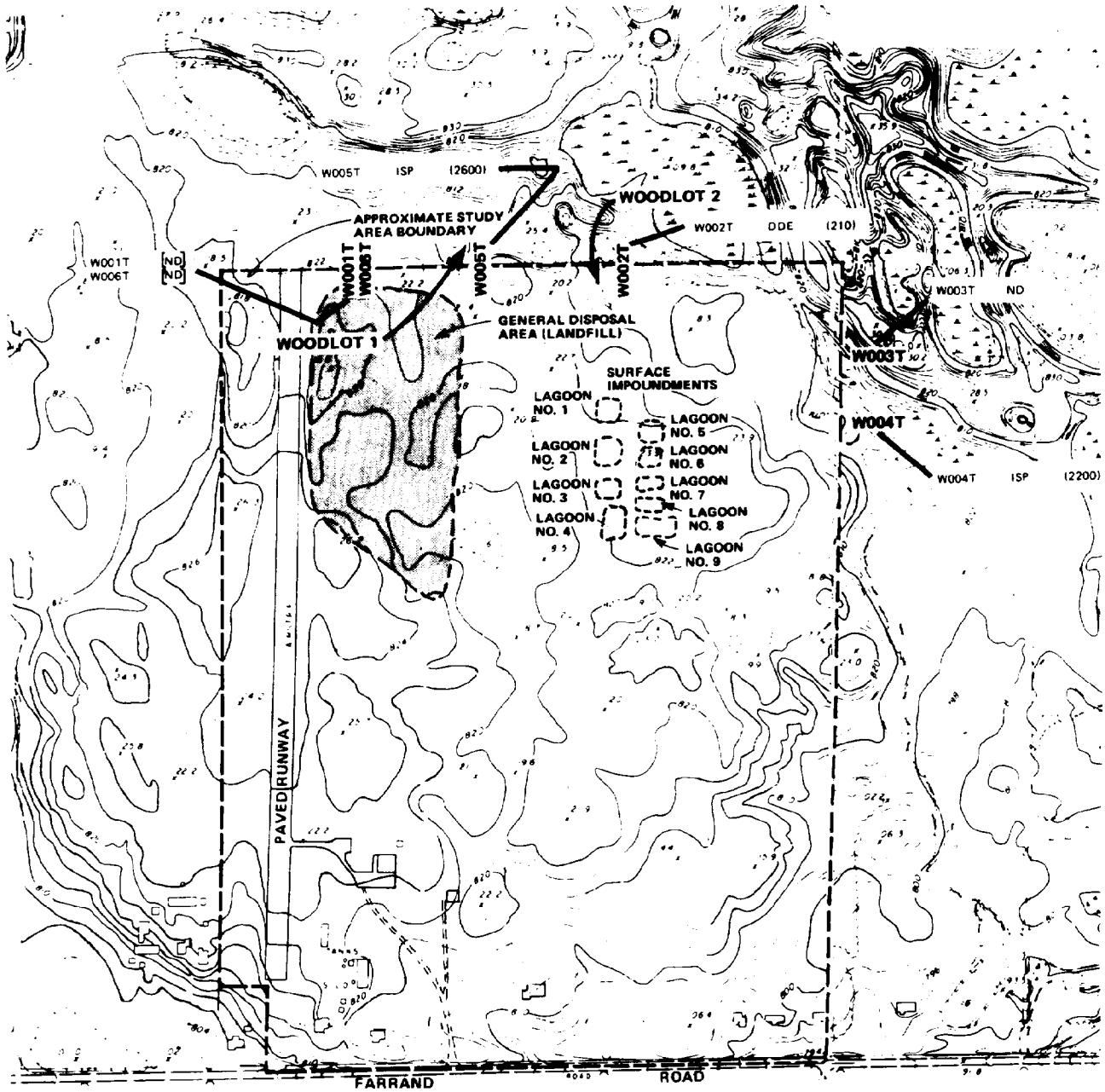


FIGURE 4-32
INORGANIC COMPOUNDS ABOVE BACKGROUND CONCENTRATIONS IN PHASE II MAMMAL SAMPLES
FOREST WASTE RI



LEGEND

[ACN 20, 20] — CONCENTRATION IN mg/kg REPORTED FOR DUPLICATE SAMPLE (WHEN TAKEN)

CONCENTRATION IN mg/kg REPORTED FOR SAMPLE

COMPOUND

(66) ESTIMATED VALUE

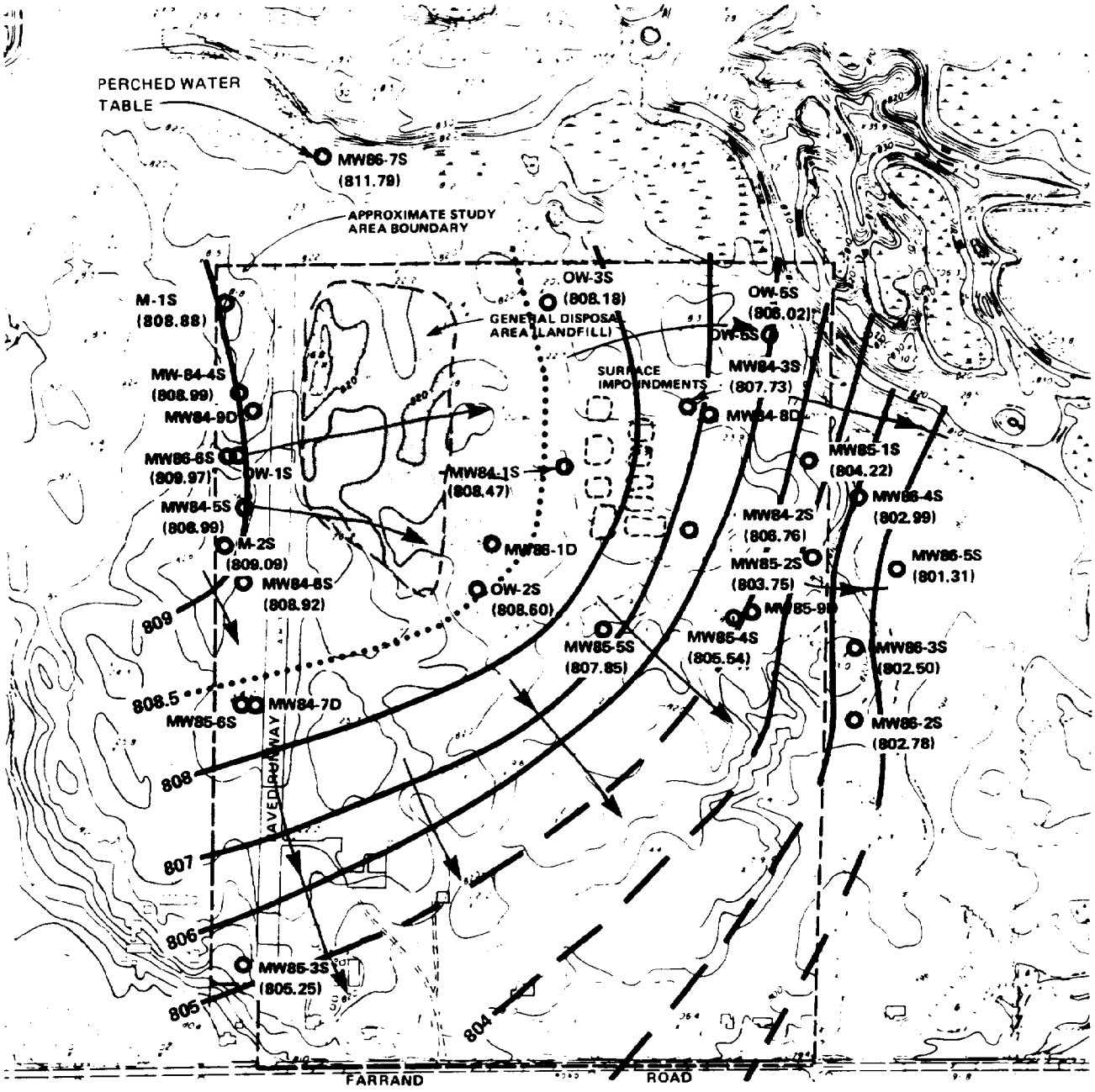
(ND) CONSTITUENT NOT DETECTED

MAMMAL SAMPLES

ORGANIC COMPOUND KEY

Abbreviation	Compound Name
DDE	4,4-DDE
ISP	Isophorone

FIGURE 4-33
ORGANIC COMPOUNDS IN PHASE II MAMMAL SAMPLES
FOREST WASTE RI



Note: Contour Interval = 1 ft.

FIGURE 1-4
GROUNDERWATER ELEVATIONS IN THE SHALLOW AQUIFER
MAY 12, 1986
FOREST WASTE FS

Table 4
INDICATOR PARAMETERS AND ACTION LEVELS

Compound	Action Level (ug/l)	
Volatile Organic Compounds	Drinking Water[a]	Aquatic Protection[b]
Acetone	3,500[c]	500
1,1-Dichloroethane	4,200[c]	--
1,1,1,-Trichloroethane	200[d]	117
Trichloroethene	5[d]	94
Toluene	2,000[e]	100
Inorganic Constituents		
Barium	1,000[e]	--
Chromium (total)	50[e]	117
Lead	50[e]	16
Nickel	700[c]	192

[a] Used for all wells.
[b] Michigan surface water quality criteria apply to offsite wells upgradient of wetlands (86-2S, 86-3S, 86-4S, and 86-5S).
[c] Risk-based target concentrations for individual chemicals.
[d] MCL
[e] MCLG

GLT458/83

Methylene chloride, although prevalent in the lagoon waste, was not selected as a plume indicator because it is a common laboratory contaminant. The list of indicator parameters may be adjusted annually after evaluating the analytical data from the sampling program.

ACTION LEVELS

The analytical results from the groundwater samples will be compared to the action levels listed in Table 4. Groundwater quality from all of the wells will be compared to action levels based on standards, criteria, and guidelines for drinking water aquifers. The U.S. EPA standards, criteria, guidelines, and the risk-based target concentrations for individual constituents are listed in Appendix A. The action levels for each compound presented in Appendix B were assigned based on a priority system established during the lagoon RD. The standards, criteria, guidelines, and risk-based target concentrations were adopted in the following order:

- Maximum Contaminant Levels (MCLs) (Safe Drinking Water Act 40 CFR 141.61 and 40 CFR 143)
- Maximum Contaminant Level Goals (MCLGs) above zero (Safe Drinking Water Act 40 CFR 141.50)
- Risk-based Target Concentrations for Individual Chemicals for Drinking Water (based on cancer potency factors and reference doses from the Superfund Public Health Evaluation Manual, and U.S. EPA IRIS data base)
- Office of Drinking Water Lifetime Health Advisories (U.S. EPA Office of Water)
- Federal Water Quality Criteria for Protection of Human Health

The standards, criteria, and guidelines above are listed in decreasing order of priority. For example, if a compound had an MCL, the action level was set at the MCL. If no MCL was specified, the MCLG was used if one was available and nonzero; if not, the risk-based target concentrations were used and so on.

Results from the wells offsite, upgradient of the wetland area, will also be compared to action levels based on the protection of surface water and aquatic life. The action levels for these wells were based on the following criteria in order of decreasing importance:

- Michigan Surface Water Quality Criteria (Rule 57(2) Guideline Levels, updated January 24, 1989)
- Federal Criteria for the Protection of Aquatic Life

Although both criteria were considered, the guidelines set by the State of Michigan were given a higher priority because, in general, they tended to be more stringent. The criteria for individual parameters are also listed in Appendix A. The action levels for other compounds detected in the groundwater are listed in Appendix B.

Several of the action levels for VOCs previously detected in groundwater are lower or equal to the CLP RAS detection limits. The compounds of concern include trichloroethene, 1,1-dichloroethene, 1,2-dichloroethane, 1,2-dichloropropane, tetrachloroethene, and 1,1,2-trichloroethane. The VOCs will be analyzed using the SAS to achieve lower detection limits to measure more accurately the concentrations near the action levels.

DATA ANALYSIS AND EVALUATION

The decision diagram outlining the actions to be taken (depending upon the analytical results), both annually and quarterly, is presented in Figure 3. The following briefly describes the decision processes.

BASELINE MONITORING

The monitoring program will begin with the collection and analysis of four discrete samples from each of the 17 wells in the monitoring program to develop baseline concentrations. All samples will be analyzed for TCL organic and inorganic parameters, and conventional parameters. Each sample will be a separate and distinct sample taken in accordance with the sampling procedures specified in the QAPP (i.e., the well will be purged between each sample using properly decontaminated sampling equipment). The analytical results will be compared to background concentrations calculated in the RI to identify the extent of lagoon-related groundwater contamination. The background concentrations for inorganic constituents are listed in Table 5. Organic compounds were not detected in the background wells during the RI. The detection of organic compounds is considered an indication of contamination.

The mean, variance, and 95 percent confidence limits of the mean will be calculated for each parameter for each well. This data will be used for the initial data base to appraise any future trends. The compounds detected above background will be compared to the plume indicator parameter list (Table 3) to determine if any additional parameters should be included as indicator parameters.

If indicator parameters are present at concentrations above background in a well initially designated for annual sampling, or if the well was initially designated for the quarterly sampling program, the well will be sampled under the quarterly sampling program. If indicator parameters are not detected in a designated annual well, the well will be sampled annually.

Appendix A
DRINKING WATER STANDARDS, CRITERIA, AND GUIDELINES, TARGET CONCENTRATIONS FOR INDIVIDUAL COMPOUNDS, AND RULE 57(2) GUIDELINE LEVELS

Table 1

Revised 6-12-89 by J. Sepesi

U.S. EPA DRINKING WATER STANDARDS, CRITERIA, AND GUIDELINES

All units ug/l except as noted	[a] Maximum Contaminant Level (MCL)		[b] Maximum Contaminant Level Goal (MCLG)		[c] Secondary Maximum Contaminant Level		[d] Federal Ambient Water Quality Criteria (FAWQC) For Protection of Human Health							[e] Office of Drinking Water Lifetime Health Advisories
							Water & Aquatic Organisms		Aquatic Organisms		Water Only			
Chemical	Final	Proposed	Final	Proposed	Final	Proposed	Toxicity Protection	1 x 10-6 Cancer Risk	Toxicity Protection	1 x 10-6 Cancer Risk	Toxicity Protection	1 x 10-6 Cancer Risk	Organoleptic Criterion	
Acenaphthene	–	–	–	–	–	–	–	–	–	–	–	–	20	–
Acrolein	–	–	–	–	–	–	320	–	780	–	540	–	–	–
Acrylamide	–	j	–	0	–	–	–	–	–	–	–	–	–	NRC
Acrylonitrile	–	–	–	–	–	–	–	0.058	–	0.65	–	0.063	–	–
Alachlor	–	2	–	0	–	–	–	–	–	–	–	–	–	NRC
Aldicarb	–	10	–	10	–	–	–	–	–	–	–	–	–	10
Aldicarb sulfoxide	–	10	–	10	–	–	–	–	–	–	–	–	–	–
Aldicarb sulfone	–	40	–	40	–	–	–	–	–	–	–	–	–	–
Aldrin	–	–	–	–	–	–	–	0.000074	–	0.000079	–	0.0012	–	–
Aluminum	–	–	–	–	–	50	–	–	–	–	–	–	–	–
Antimony	–	–	–	–	–	–	146	–	45000	–	146	–	–	–
Arsenic	50	–	–	–	–	–	–	0.0022	–	0.0175	–	0.0025	–	50
Asbestos	–	7	–	7.0 f	–	–	–	0.03 f	–	–	–	0.030 f	–	–
Atrazine	–	3	–	3	–	–		–	–	–	–	–	–	–
Barium	1000	5000	–	5000	–	–	–	–	–	–	–	–	–	1500
Benzene	5	–	0	–	–	–	–	0.66	–	40	–	0.67	–	NRC
Benzidine	–	–	–	–	–	–	–	0.00012	–	0.00053	–	0.00015	–	–
Benzo[a]anthracene	–	–	–	–	–	–	–	h	–	h	–	h	–	–
Benzo[a]pyrene	–	–	–	–	–	–	–	h	–	h	–	h	–	–
Benzo[b]fluoranthene	–	–	–	–	–	–	–	h	–	h	–	h	–	–
Benzo[k]fluoranthene	–	–	–	–	–	–	–	h	–	h	–	h	–	–
Benzo[g,h,i]perylene	–	–	–	–	–	–	–	h	–	h	–	h	–	–
Beryllium	–	–	–	–	–	–	–	0.0037	–	0.0641	–	0.0039	–	–
bis(2-chloroisopropyl) ether	–	–	–	–	–	–	34.7	–	4.36	–	34.7	–	–	–
bis(2-chloromethyl) ether	–	–	–	–	–	–	–	0.00000376	–	0.00184	–	0.0000039	–	–
bis(2-chloroethyl) ether	–	–	–	–	–	–	–	0.03	–	1.36	–	0.03	–	–
bis(2-ethylhexyl) phthalate	–	–	–	–	–	–	15000	–	50000	–	21000	–	–	–
Bromodichloromethane	100 g	–	–	–	–	–	i	–	i	–	i	–	–	–
Bromoform	100 g	–	–	–	–	–	–	–	–	–	–	–	–	–
2-Butanone	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cadmium	10	5	–	5	–	–	10	–	–	–	10	–	–	170
Carbofuran	–	40	–	40	–	–	–	–	–	–	–	–	–	5
Carbon tetrachloride	5	–	0	–	–	–	–	0.4	–	6.94	–	0.42	–	36
Chlorobenzene (mono)	–	100	–	100	–	–	488	–	15050	–	488	–	–	NRC
Chlordane	–	2	–	0	–	–	–	0.00046	–	0.00048	–	0.022	–	300
Chloride	–	–	–	–	*****	–	–	–	–	–	–	–	–	NRC
Chloroform	100 g	–	–	–	–	–	–	0.19	–	15.7	–	0.19	–	–
2-Chlorophenol	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–
3-Chlorophenol	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–
4-Chlorophenol	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–
Chromium	50	100	–	100	–	–	–	–	–	–	–	–	–	120
Chromium (hexavalent)	–	–	–	–	–	–	50	–	–	–	** 50	–	–	–
Chromium (trivalent)	–	–	–	–	–	–	170000	–	3433000	–	179000	–	–	–
Chrysene	–	–	–	–	–	–	–	h	–	h	–	h	–	–
Color	–	–	–	–	15 m	–	–	–	–	–	–	–	–	–
Copper	–	1300	–	1300	1000	–	–	–	–	–	–	–	1000	–

Table 1

Revised 6-12-89 by J. Sepesi

U.S. EPA DRINKING WATER STANDARDS, CRITERIA, AND GUIDELINES

All units ug/l except as noted	a		b		c		d							e
	Maximum Contaminant Level (MCL)		Maximum Contaminant Level Goal (MCLG)		Secondary Maximum Contaminant Level		Federal Ambient Water Quality Criteria (FAWQC) For Protection of Human Health							Office of Drinking Water Lifetime Health Advisories
							Water & Aquatic Organisms		Aquatic Organisms		Water Only			
Chemical	Final	Proposed	Final	Proposed	Final	Proposed	Toxicity Protection	1 x 10-6 Cancer Risk	Toxicity Protection	1 x 10-6 Cancer Risk	Toxicity Protection	1 x 10-6 Cancer Risk	Organoleptic Criterion	
Corrosivity	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide	-	-	-	-	n	-	200	-	-	-	200	-	-	154
DDT	-	-	-	-	-	-	-	0.000024	-	0.000024	-	>0.0012	-	-
2,4-D	100	70	-	70	-	-	-	-	-	-	-	-	-	70
DBCP	-	0.2	-	0	-	-	-	-	-	-	-	-	-	NRC
Dibenzo[a,h]anthrancene	-	-	-	-	-	-	-	h	-	h	-	h	-	-
Dibutyl phthalate	-	-	-	-	-	-	34000	-	154000	-	44000	-	-	-
1,2-Dichlorobenzene (o)	-	600	-	600	-	10	400	-	2600	-	470	-	-	620
1,3-Dichlorobenzene (m)	-	-	-	-	-	-	400	-	2600	-	470	-	-	620
1,4-Dichlorobenzene (p)	75	-	75	-	-	5	400	-	2600	-	470	-	-	75
Dichlorobenzidine	-	-	-	-	-	-	-	0.01	-	0.02	-	0.0207	-	-
1,2-Dichloroethane	5	-	0	-	-	-	-	0.94	-	243	-	0.94	-	NRC
1,1-Dichloroethene	7	-	7	-	-	-	-	0.033	-	1.85	-	0.033	-	7
cis-1,2-Dichloroethene	-	70	-	70	-	-	-	-	-	-	-	-	-	70
trans-1,2-Dichloroethene	-	100	-	100	-	-	-	-	-	-	-	-	-	70
2,3-Dichlorophenol	-	-	-	-		-	-	-	-	-	-	-	0.04	-
2,4-Dichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
2,5-Dichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
2,6-Dichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
3,4-Dichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
2,4-Dimethylphenol	-	-	-	-	-	-	-	-	-	-	-	-	400	-
1,2-Dichloropropane	-	5	-	0	-	-	-	-	-	-	-	-	-	-
Dichloropropene	-	-	-	-	-	-	87	-	14100	-	87	-	-	-
Dieldrin	-	-	-	-	-	-	-	0.000071	-	0.000076	-	0.0011	-	NRC
Diethyl phthalate	-	-	-	-	-	-	350000	-	1800000	-	434000	-	-	-
Dimethylphthalate	-	-	-	-	-	-	313000	-	2900000	-	350000	-	-	-
Dinitrophenol	-	-	-	-	-	-	70	-	13.4	-	70	-	-	-
2,4-Dinitro-methylphenol	-	-	-	-	-	-	14.3	-	765	-	13.4	-	-	-
2,4-Dinitrotoluene	-	-	-	-	-	-	-	0.11	-	9.1	-	0.11	-	-
Dioxane	-	-	-	-	-	-	-	-	-	-	-	0.46	-	NRC
Diphenylhydrazine	-	-	-	-	-	-	-	0.042	-	0.56	-	-	-	-
Endosulfan	-	-	-	-	-	-	74	-	159	-	138	-	-	-
Endrin	0.2	-	-	-	-	-	1	-	-	-	1	-	-	0.32
Epichlorohydrin	-	j	-	0	-	-	-	-	-	-	-	-	-	NRC
Ethylbenzene	-	700	-	700	-	30	1400	-	3280	-	2400	-	-	3400
Ethylenedibromide	-	0.05	-	0	-	-	-	-	-	-	-	-	-	NRC
Ethylene glycol	-	-	-	-	-	-	-	-	-	-	-	-	-	7
Fluoranthene	-	-	-	-	-	-	42	-	54	-	188	-	-	-
Fluoride	-	-	-	-	2000	-	-	-	-	-	-	-	-	-
Foaming Agents	-	-	-	-	500	-	-	-	-	-	-	-	-	-
Halomethanes	-	-	-	-	-	-	-	0.19 i	-	15.7	-	0.19 i	-	-
alpha-HCCH (BHC)	-	-	-	-	-	-	-	0.0092	-	0.031	-	0.013	-	-
beta-HCCH (BHC)	-	-	-	-	-	-	-	0.0163	-	0.0547	-	0.023	-	-
gamma-HCCH (lindane)	4	0.2	-	0.2	-	-	-	0.0186	-	0.0625	-	0.017	-	7000
Heptachlor	-	0.4	-	0	-	-	-	0.00028	-	0.00029	-	0.011	-	2
Heptachlor epoxide	-	0.2	-	0	-	-	-	-	-	-	-	-	-	-

Table 1

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U.S. EPA DRINKING WATER STANDARDS, CRITERIA, AND GUIDELINES

All units ug/l except as noted

Chemical	[a] Maximum Contaminant Level (MCL) Final	[a] MCL Proposed	[b] Maximum Contaminant Level Goal (MCLG) Final	[b] MCLG Proposed	[c] Secondary Maximum Contaminant Level Final	[c] SMCL Proposed	[d] Federal Ambient Water Quality Criteria (FAWQC) For Protection of Human Health: Water & Aquatic Organisms — Toxicity Protection	Water & Aquatic Organisms — 1 x 10-6 Cancer Risk	Aquatic Organisms — Toxicity Protection	Aquatic Organisms — 1 x 10-6 Cancer Risk	Water Only — Toxicity Protection	Water Only — 1 x 10-6 Cancer Risk	Organoleptic Criterion	[e] Office of Drinking Water Lifetime Health Advisories
Hexachlorobenzene	–	–	–	–	–	–	–	0.00072	–	0.00074	–	0.021	–	NRC
Hexachlorobutadiene	–	–	–	–	–	–	–	0.45	–	50	–	0.45	–	–
Hexachlorocyclopentadiene	–	–	–	–	–	–	206	–	14800	–	206	–	–	–
Hexachloroethane	–	–	–	–	–	–	–	1.9	–	8.74	–	2.4	–	–
Iron	–	–	–	–	300	–	–	–	–	–	–	–	–	–
Isophorone	–	–	–	–	–	–	5200	–	520000	–	5200	–	–	–
Lead	50	5	–	20	–	–	50	–	–	–	50	–	–	20
Manganese	–	–	–	–	50	–	–	–	–	–	–	–	–	–
Mercury	2	2	–	2	–	–	0.144	–	0.146	–	10	–	–	1.1
Methoxychlor	100	400	–	400	–	–	–	–	–	–	–	–	–	340
2-Methyl-4-chlorophenol	–	–	–	–	–	–	–	–	–	–	–	–	1800	–
3-Methyl-4-chlorophenol	–	–	–	–	–	–	–	–	–	–	–	–	3000	–
3-Methyl-6-chlorophenol	–	–	–	–	–	–	–	–	–	–	–	–	20	–
Methylene chloride	–	–	–	–	–	–	–	–	–	–	–	–	–	NRC
4-Methylphenol	–	–	–	–	–	–	i	–	i	–	–	–	0.1	–
Nickel	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitrate	–	10000 q	–	10000 q	–	–	13.4	–	100	–	15.4	–	–	150
Nitrite	–	1000 r	–	1000 r	–	–	–	–	–	–	–	–	–	–
Nitrobenzene	–	–	–	–	–	–	–	–	–	–	–	–	–	–
N-Nitrosodimethylamine	–	–	–	–	–	–	19800	–	2130000	–	19800	–	–	–
N-Nitrosodiethylamine	–	–	–	–	–	–	–	0.0014	–	16	–	0.0014	–	–
N-Nitrosodibutylamine	–	–	–	–	–	–	–	0.0008	–	1.2	–	0.0008	–	–
N-Nitrosopyrrolidine	–	–	–	–	–	–	–	0.0064	–	0.587	–	0.0064	–	–
N-Nitrosodiphenylamine	–	–	–	–	–	–	–	0.016	–	91.1	–	0.016	–	–
Odor	–	–	–	–	3 o	–	–	4.9	–	16.1	–	4.9	–	–
Oxamyl	–	–	–	–	–	–	–	–	–	–	–	–	–	–
PCB	–	0.5	–	0	–	–	–	–	–	–	–	–	–	175
Pentachlorobenzene	–	–	–	–	–	–	–	0.000079	–	0.000079	–	0.013	–	–
Pentachlorophenol	–	200	–	200	–	30	74	–	85	–	570	–	–	–
pH	–	–	–	–	5-8.5 p	–	1010	–	29400	–	1010	–	30	220
Phenol	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Selenium	10	50	–	50	–	–	3500	–	769000	–	3500	–	–	–
Silver	50	–	–	–	–	90	10	–	–	–	10	–	–	–
Styrene	–	5/100 k	–	0/100 l	–	10	50	–	–	–	50	–	–	–
Sulfate	–	–	–	–	*****	–	–	–	–	–	–	–	–	140
2,3,7,8-TCDD	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,2,4,5-Tetrachlorobenzene	–	–	–	–	–	–	–	0.000000013	–	0.00000022	–	0.000000018	–	NRC
Tetrachloroethene	–	5	–	0	–	–	38	–	48	–	180	–	–	–
1,1,2,2-Tetrachloroethane	–	–	–	–	–	–	–	0.80	–	8.85	–	0.88	–	10
2,3,4,6-Tetrachlorophenol	–	–	–	–	–	–	–	0.17	–	10.7	–	0.17	–	–
Thallium	–	–	–	–	–	–	–	–	–	–	–	–	1.0	–
Toluene	–	2000	–	2000	–	40	13	–	48	–	17.8	–	–	–
Total dissolved solids	–	–	–	–	*****	–	14300	–	424000	–	*15000	–	–	2420
Toxaphene	5	5	–	0	–	–	–	–	–	–	–	–	–	–
2,4,5-T	–	–	–	–	–	–	–	0.00071	–	0.00073	–	0.026	–	–
2,4,5-TP	–	50	–	50	–	–	–	–	–	–	–	–	–	21
														52

Table 1

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U.S. EPA DRINKING WATER STANDARDS, CRITERIA, AND GUIDELINES

All units ug/l except as noted	[a] Maximum Contaminant Level (MCL)		[b] Maximum Contaminant Level Goal (MCLG)		[c] Secondary Maximum Contaminant Level		[d] Federal Ambient Water Quality Criteria (FAWQC) For Protection of Human Health							[e] Office of Drinking Water Lifetime Health Advisories
							Water & Aquatic Organisms		Aquatic Organisms		Water Only			
Chemical	Final	Proposed	Final	Proposed	Final	Proposed	Toxicity Protection	1 x 10-6 Cancer Risk	Toxicity Protection	1 x 10-6 Cancer Risk	Toxicity Protection	1 x 10-6 Cancer Risk	Organoleptic Criterion	
1,1,1-Trichloroethane	200	-	200	-	-	-	18400	-	1030000	-	19000	-	-	200
1,1,2-Trichloroethane	-	-	-	-	-	-	-	0.6	-	41.8	-	0.60	-	-
Trichloroethene	5	-	0	-	-	-	-	2.7	-	80.7	-	2.8	-	NRC
2,4,5-Trichlorophenol	-	-	-	-	-	-	2600	-	-	-	2600	-	1000	-
2,4,6-Trichlorophenol	-	-	-	-	-	-	-	1.2	-	3.6	-	1.8	-	-
Trihalomethane (total)	100 g	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	2	-	0	-	-	-	-	2.0	-	525	-	2	-	NRC
Xylenes (total)	-	10000	-	10000	-	20	-	-	-	-	-	-	-	400
Zinc	-	-	-	-	5000	-	-	-	-	-	5000	-	-	-

a. Maximum Contaminant Levels (MCLs) are enforceable drinking water standards, developed under the Safe Drinking Water Act, that are set as close to MCLGs as feasible (with the use of the best technology, treatment techniques taking into consideration cost). MCLs are part of National Primary Drinking Water Regulations. MCLs are listed at 40 CFR.61 for organic contaminants and 40 CFR 141.62 for inorganic contaminants. Proposed MCLs issued on May 22, 1989 (54 FR 22062) except lead and copper which were issued August 24, 1988 (53 FR 32259).

b. Maximum Contaminant Level Goal (MCLGs) are non-enforceable health goals, developed under the Safe Drinking Water for drinking water. They are set at levels at which no known or anticipated adverse effects on the health of persons occur and which allow an adequate margin of safety. MCLGs were previously named RMCLs. MCLGs are listed at 40 CFR 141.50 for organic chemicals and 40 CFR 141.51 for inorganic chemicals. Proposed MCLGs issued on May 22, 1989 (54 FR 22062) except lead and copper which were issued August 24, 1988 (53 FR 32259).

c. Secondary Maximum Contaminant Levels (SMCLs) are part of the National Secondary Drinking Water Regulations developed under the Safe Drinking Water Act. They are not federally enforceable but offer guidance to water systems and states on contaminant levels that protect public welfare. They are based on odor, aesthetics, and appearence. They are listed at 40 CFR 143. Proposed SMCLs issued on May 22, 1989 (54 FR 22062).

d. Federal Ambient Water Quality Criteria (FAWQC) are nonenforceable guidance, developed under the Clean Water Act to protect designated uses of surface waters. The criteria presented in this table are for the use of surface waters for potable water supply and fishing. The criteria presented are for protection against carcinogenic health effects, noncarcionogenic health effects, and organoleptic effects. EPA considers the maximum protection of human health from carcinogenic effects to be zero exposure. EPA recognized the zero level as unobtainable and presented concentrations representing a range of risks from 10-4 to 10-7. This table presents the concentration estimated to be associated with a 10-6 lifetime cancer risk. The toxicity protection criteria for noncarcinogenic effects presents concentrations which are not expected to produce adverse effects in humans. Organoleptic effects are taste and odor problems and are not health based. The FAWQC are listed at 45 FR 79318-79379; November 28, 1980. This table lists four sets of criteria: protection from ingestion of contaminated aquatic organisms and contaminated water; protection from ingestion of contaminated aquatic organisms; protection from ingestion of contaminated water; and protection from organoleptic effects. The third set of criteria are not published FAWQC but criteria modified for the application to groundwater contamination situations at Superfund sites. These values were published in the "Superfund Public Health Evaluation Manual" (U.S. EPA 1986).

e. Drinking water health advisories are informal technical guidance issued by the U.S. EPA Office of Drinking Water (ODW). They are not legally enforceable standards. They are subject to change as new information becomes available. They are based on data describing noncarcinogenic endpoints. Lifetime health advisories describe concentrations of drinking water contaminants at which health effects would not be anticipated to occur over a lifetime exposure, accounting for other sources of exposure. No lifetime health advisories are issued for carcinogens. A "NRC" is indicated where health advisories have been issued for the chemical for less than lifetime exposures.

f. Million fibers/liter.

g. Standard for total trihalomethane. Trihalimethanes include chloroform, bromoform, bromodichloromethane, and chlorodibromomethane.

h. Criteria set for all carcinogenic PAH's: water only = 0.0031 ug/l; water and organisms = 0.0028 ug/l; and organism only = 0.031 ug/l.

i. Halomethane criterion is for chloromethane, bromomethane, dichloromethane, bromodichloromethane, tribromomethane, dichlorodofluoromethane, trichlorofluoromethane, or combinations of these chemicals.

j. No MCL issued for acrylamide or epichlohydrin because currently, analytical methods do not exist which accurately measure these chemicals at any level. A treatment technique is issued in lieu of an MCL.

k. EPA proposes MCLs of 100 ug/l based on a Group C carcinogen classification and 5 ug/l based on a B2 classification.

l. EPA proposes MCLGs of 100 ug/l based on a Group C carcinogen classification and 0 ug/l based on a B2 classification.

m. Color units

n. Non-corrosive

o. Threshold odor number

p. Standard units

q. Nitrate as N

r. Nitrite as N

Table 2

DEFINITIONS OF STANDARDS, CRITERIA, AND GUIDELINES

MAXIMUM CONTAMINANT LEVELS (MCLs)

MCLs are enforceable drinking water standards that the Safe Drinking Water Act (SWDA) directs U.S. EPA to set as close to the MCLGs as feasible. Feasible means feasible with the best technology, treatment techniques, and other means which the U.S. EPA administrator finds available (taking cost into consideration). MCLs are part of the National Primary Drinking Water Regulations (NPDWR) for public water supplies. MCLs are listed at 40 CFR 141.61

MAXIMUM CONTAMINANT LEVEL GOALS (MCLGs)

MCLGs are nonenforceable drinking water health goals set by U.S. EPA under the Safe Drinking Water Act. U.S. EPA is to establish MCLGs at the level which no known or anticipated adverse effects on the health of persons occur and which allow an adequate margin of safety. MCLGs were previously termed Recommended Maximum Contaminant Levels (RMCLs). MCLGs are listed at 40 CFR 141.50.

SECONDARY MAXIMUM CONTAMINANT LEVELS (SMCLs)

Secondary MCLs are National Secondary Drinking Water Regulations (NSDWRs) that U.S. EPA are authorized to promulgate under the SDWA. NSDWRs apply to public water systems and specify the maximum contaminant levels which, in the judgement of the U.S. EPA administrator are requisite to protect public welfare. They may apply to any contaminant in drinking water which may adversely affect the odor or appearance of such water and consequently may cause a substantial number of persons served by the public water system to discontinue its use, or which may adversely affect the public welfare. Secondary MCLs are not federally enforceable. Secondary MCLs are listed at 40 CFR 143.

FEDERAL AMBIENT WATER QUALITY CRITERIA (FAWQC)

FAWQC are nonenforceable guidelines developed by U.S. EPA under the Clean Water Act that are used by the states to set water quality standards for surface water. EPA develops two kinds of criteria, one for the protection of human health and another for the protection of aquatic life. FAWQC quantitatively address the levels of pollutants in water that will ensure water quality adequate to support a specified use. These criteria are based solely on data and scientific judgments on the relationship between pollutant concentrations and environmental and human health effects and do not reflect considerations of economic or technological feasibility.

Table 2

DEFINITIONS OF STANDARDS, CRITERIA, AND GUIDELINES

The first water quality criteria were published in *Quality Criteria for Water: 1973* (the Blue Book) and were updated in *Quality Criteria for Water: 1976* (the Red Book). In 1980 the Ambient Water Quality Criteria (45 FR 79318) for the 65 consent decree priority pollutants were published. The FAWQC for aquatic life have been periodically updated since 1980.

FAWCQ for Human Health Protection

The purpose of FAWQC for human health protection is to identify protective levels from two routes of exposure -- exposure from drinking the water and from consuming aquatic organisms, primarily fish. There are criteria provided for exposure from both routes, and from fish consumption alone. The criteria identify concentrations associated with specified cancer risk levels (10-4, 10-6, and 10-7) for carcinogens or threshold level concentrations for noncarcinogens that represent the water concentrations which would prevent adverse (chronic toxicity) health effects. There are also nonhealth based criteria for chemicals with organoleptic properties (i.e., taste or odor) representing the water concentration that would prevent taste or odor concerns.

The FAWQC without modification are not appropriate for exposures through groundwater or other situations where exposure is through drinking water consumption alone. The FAWQC values can be adjusted to reflect only exposure from drinking the water. Adjusted FAWQC are presented in the *Superfund Public Health Evaluation Manual* (U.S. EPA, 1986).

FAWQC for Aquatic Life Protection

The FAWQC for the protection of aquatic life present two sets of values, one based on the protection of aquatic life from acute exposure and the other from chronic exposures. Where insufficient data existed to set a criterion, the lowest reported acute or chronic effects level published in the literature was provided.

OFFICE OF DRINKING WATER HEALTH ADVISORIES

The health advisories are nonenforceable guidelines that present the U.S. EPA Office of Water's most recent assessment of concentrations of contaminants in drinking water at which adverse effects (noncarcinogenic endpoints of toxicity) would not be anticipated to occur. A margin of safety is included to protect sensitive members of the population. These values are subject to change as new health effects information becomes available. They are specified for 1-day, 10-day, longer term (90 days to 1 year), and lifetime exposure periods. The lifetime health advisories are not developed for carcinogens.

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Table 3

[a] OFFICE OF DRINKING WATER HEALTH ADVISORIES

Chemical	[b] 1 Day Health Advisory ug/l	[c] 10 Day Health Advisory ug/l	[d] Longer Term Health Advisory		[e] DWEL	[f] Lifetime HA
			Child ug/l	Adult ug/l	Adult ug/l	Adult ug/l
Acrylamide	1500	300	20	70	7	NRC
Alachlor	100	100	100	-	7	NRC
Aldicarb	10	10	10	42	40	10
Arsenic	50	50	50	50	50	50
Barium	510	510	510	1800	1800	1500
Benzene	235	235	NRC	NRC	NRC	NRC
2-Butanone (MEK)	75000	7500	2500	8600	860	170
Cadmium	43	43	5	18	18	5
Carbofuran	50	50	50	180	180	36
Carbon tetrachloride	4000	160	71	250	25	-
Chlorobenzene	4300	4300	4300	15000	1510	300
Chlordane	63	63	0.05	-	2	NRC
Chromium(total)	1400	1400	240	840	170	120
Cyanide	220	220	220	770	770	154
2,4-D	1100	300	-	-	350	70
DBCP	200	50	NRC	NRC	NRC	NRC
1,2-Dichlorobenzene (o)	8930	8930	8930	31250	3125	620
1,3-Dichlorobenzene (m)	8930	8930	8930	31250	3125	620
1,4-Dichlorobenzene (p)	10700	10700	10700	37500	3750	75
1,2-Dichloroethane	740	740	740	2600	NA	NA
1,1-Dichloroethene	2000	1000	1000	3500	350	7
Cis-1,2-Dichloroethene	4000	1000	1000	3500	350	70
Trans-1,2-Dichloroethene	20000	1430	1430	5000	350	70
1,2-Dichloropropane	-	90	-	-	-	-
Dioxane	4120	412	NRC	NRC	NRC	NRC
Endrin	20	5	4.5	16	1.6	0.32
Epichlorohydrin	140	140	(70)	70	70	NRC
Ethylbenzene	32000	3200	-	-	3400	3400
Ethylenebromide	8	8	NRC	NRC	NRC	NRC
Ethyleneglycol	19000	5500	5500	19250	35000	7000
gamma-HCCH(Lindane)	1200	1200	33	120	10	2
Heptachlor	10	10	-	-	-	-
Heptachlor Epoxide	10	10	-	-	-	-
Hexachlorobenzene	50	50	50	175	28	NRC
Hexane	13000	4000	4000	14000	-	-
Lead	NA	NA	20	20	20	20
Mercury (inorganic)	1.58	1.58	1.58	-	5.5	1.1
Methoxychlor	6400	2000	-	-	1700	340
Methylene Chloride	13300	1500	-	-	1750	NRC
Nickel	1000	1000	100	350	350	150

See last page for footnotes.

Revised 1-11-89 by J. Sepes[illegible] Table 3

OFFICE OF DRINKING WATER HEALTH ADVISORIES[a]

Chemical	1 Day Health Advisory[b] ug/l	10 Day Health Advisory[c] ug/l	Longer Term Health Advisory[d]		DWEL[e]	Lifetime HA[f]
			Child ug/l	Adult ug/l	Adult ug/l	Adult ug/l
Oxamyl	175	175	175	-	875	175
Pentachlorophenol	1000	300	300	1050	1050	220
Styrene	22500	2000	2000	7000	7000	140
2,3,7,8-TCDD	0.001	0.0001	0.00001	0.000035	0.000035	NRC
Tetrachloroethene	2000	2000	1400	5000	500	10
Toluene	21500	3460	3460	3460	12100	2420
Toxaphene	500	40	-	-	-	-
2,4,5-TP	200	200	70	-	260	52
1,1,1-Trichloroethane	140000	35000	35000	125000	1000	200
Trichloroethene	-	-	-	-	260	NRC
Vinyl Chloride	2600	2600	13	46	NRC	NRC
Xylenes	12000	7800	7800	27300	2200	440

a. Drinking water health advisories from U.S. EPA Office of Drinking Water. Subject to change as new studies are evaluated. Based on noncarcinogenic health effects.

b. Based on ingestion of 1 liter/day by a 10 kg child. One day exposure.

c. Based on ingestion of 1 liter/day by a 10 kg child. Ten day exposure.

d. Longer term advisories based on ingestion of 1 liter/day for a 10-kg child and 2 liters/day for a 70-kg adult. Assumes an exposure period of 90 days.

e. Drinking Water Equivalent Level (DWEL)-Lifetime health advisory that assumes 100% of the exposure comes from the ingestion of water. Based on ingestion of 2 liter/day for a 70-kg adult.

f. Lifetime health adisories assumes that other sources besides water contribute to exposure. Where other source contributions are not known, a 20% drinking water contribution is assumed. Based on ingestion of 2 liters/day for a 70-kg adult.

Revised 1-11-89 by J. Sepesi

Table 4

CRITERIA FOR AQUATIC LIFE PROTECTION

Chemical	Federal water Quality Criteria[a] Acute Criteria ug/l	Federal water Quality Criteria[a] Chronic Criteria ug/l	Lowest Reported Effects Level[b] Acute ug/l	Lowest Reported Effects Level[b] Chronic ug/l
Acenaphthene	-	-	1700	520
Acrolein	-	-	68	21
Acrylonitrile	-	-	7550	2600
Aldrin	4 (2)	-	-	-
Antimony	-	-	9000	1600
Arsenic	360 (3)	190 (3)	3243	812
Barium	-	-	5000	-
Benzene	-	-	5300	-
Benzidine	-	-	2500	-
Beryllium	-	-	130	5.3
Cadmium	8.6 (3) *	2.0 (3) *	1	0.15
Carbon tetrachloride	-	-	35200	-
Chlorobenzene	-	-	250	50
Chlordane	2.4 (2)	0.0043 (2)	-	-
Chloroform	-	-	28900	1240
2-Chloronaphthalene	-	-	1600	-
2-Chlorophenol	-	-	500000	-
3-Chlorophenol	-	-	500000	-
4-Chlorophenol	-	-	500000	-
Chromium(hexavalent)	16 (3)	11 (3)	-	-
Chromium(trivalent)	3064 (3) *	365 (3) *	2221	66
Copper	34 (3) *	21 (3) *	-	-
Cyanide	22 (3)	5.2 (3)	44.73	7.849
DDE	-	-	1050	-
DDT	1.1 (2)	0.0010 (2)	-	-
1,2-Dichlorobenzene (o)	-	-	1120	763
1,3-Dichlorobenzene (m)	-	-	1120	763
1,4-Dichlorobenzene (p)	-	-	1120	763
1,2-Dichloroethane	-	-	118000	20000
1,1-Dichloroethene	-	-	11600	-
Cis-1,2-Dichloroethene	-	-	11600	-
Trans-1,2-Dichloroethene	-	-	11600	-
1,2-Dichloropropane	-	-	23000	5700
Dichloropropene	-	-	23000	5700
Dieldrin	1.0 (2)	0.0019 (2)	-	-
Diethyl Phthalate	-	-	940	3
Dimethylphthalate	-	-	940	3

See last page for explaination of footnotes

Revised 1-11-89 by J. Sepesi Table 4

CRITERIA FOR AQUATIC LIFE PROTECTION

Chemical	Federal Water Quality Criteria[a] Acute Criteria ug/l	Federal Water Quality Criteria[a] Chronic Criteria ug/l	Lowest Reported Effects Level[b] Acute ug/l	Lowest Reported Effects Level[b] Chronic ug/l
2,4-Dichlorophenol	-	-	2020	365
Di-n-butyl Phthalate	-	-	940	3
2,4-Dimethylphenol	-	-	2120	-
2,4-Dinitrotoluene	-	-	330	230
Diphenylhydrazine	-	-	270	-
Endosulfan	0.22 (2)	0.056 (2)	-	-
Endrin	0.18 (2)	0.0023 (2)	-	-
Ethylbenzene	-	-	32000	-
Fluoranthene	-	-	3980	-
Halomethanes	-	-	11000	-
alpha-HCCH(BHC)	-	-	100	-
beta-HCCH(BHC)	-	-	100	-
gamma-HCCH(Lindane)	2.0 (2)	0.080 (2)	-	-
Heptachlor	0.52 (2)	0.0038 (2)	-	-
Hexachlorobutadiene	-	-	90	9.3
Hexachlorocyclopentadiene	-	-	7.0	5.2
Iron	-	1.0 (1)	-	-
Isophorone	-	-	117000	-
Lead	197 (3) *	7.7 (3) *	-	-
Mercury (inorganic)	2.4 (3)	0.012 (3)	-	-
Methoxychlor	-	0.03 (1)	-	-
Nickel	3124 (2) *	162 (2) *	-	-
Nitrobenzene	-	-	27000	-
N-Nitrosodimethylamine	-	-	5850	-
N-Nitrosodiethylamine	-	-	5850	-
N-Nitrosodi-n-butylamine	-	-	5850	-
N-Nitrosopyrrolidine	-	-	5850	-
N-Nitrosodiphenylamine	-	-	5850	-
PCB's	2.0 (2)	0.014 (2)	-	-
Pentachlorophenol	-	-	55	3.2
Phenol	-	-	10200	2560
Selenium	20 (5)	5 (5)	-	-
Silver	13.4 (2) *	-	-	0.12
Tetrachloroethene	-	-	5280	840
1,1,2,2-Tetrachloroethane	-	-	-	2400
2,3,4,6-Tetrachlorophenol	-	-	970	30

See last page for explaination of footnotes.

Revised 1-11-89 by J. Sepesi

Table 4

CRITERIA FOR AQUATIC LIFE PROTECTION

Chemical	Federal Water Quality Criteria[a] Acute Criteria ug/l	Federal Water Quality Criteria[a] Chronic Criteria ug/l	Lowest Reported Effects Level[b] Acute ug/l	Lowest Reported Effects Level[b] Chronic ug/l
Thallium	-	-	1400	40
Toluene	-	-	17500	-
Toxaphene	1.6 (2)	0.013 (2)	-	-
1,1,1-Trichloroethane	-	-	18000	-
1,1,2-Trichloroethane	-	-	18000	2400
Trichloroethene	-	-	45000	-
2,4,6-Trichlorophenol	-	-	970	30
Xylenes	-	-	-	-
Zinc	211 (4) *	191 (4) *	-	-

FOOTNOTES:

* Criterion is dependent on the hardness of the water.
  Assumed Hardness (mg/l) 200.0

a. Federal Water Quality Criteria for Protection of Freshwater Aquatic Life. From the following sources:
   (1) From "Quality Criteria for Water" (Red Book), U.S. EPA; July 1976
   (2) From 45 FR 79318, November 1980. Ambient Water Quality Criteria: Availability of Documents. Acute criterion reflects a concentration which should not be exceeded at any time Chronic criterion reflects an average concentration over a 24-hour period.
   (3) From 50 FR 30784, July 29, 1985. Ambient Water Quality Criteria: Availability of Documents. Acute criterion reflects a one hour average not to be exceeded more than once every three years on average. Chronic criterion reflects a 4-day average concentration not to be exceeded more than once in three years on the average.
   (4) From 52 FR 6213, March 2, 1987. Ambient Water Quality Criteria: Availability of Documents. Acute criterion reflects a one hour average not to be exceeded more than once every three years on average. Chronic criterion reflects a 4-day average concentration not to be exceeded more than once in three years on the average.
   (5) From 53 FR 177, January 5, 1988. Ambient Water Quality Criteria: Availability of Documents. Acute criterion reflects a one hour average not to be exceeded more than once every three years on average. Chronic criterion reflects a 4-day average concentration not to be exceeded more than once in three years on the average.

b. Not enough data was available to derive a numerical national water quality criteria for aquatic life protection for these chemicals. Values reflect lowest reported effects levels. From 45 FR 79318 November 1980.

Table 5

RISK-BASED TARGET DRINKING WATER CONCENTRATIONS FOR INDIVIDUAL CHEMICALS
NONCARCINOGENIC HEALTH EFFECTS
BASED ON INGESTION

Chemical	Reference dose (RfD) mg/kg/day	Source a	Target concentration ug/l
Acetone	0.1	IRIS	3500
Aldrin	0.00003	IRIS	1.05
Antimony	0.0004	IRIS	14
Arsenic	0.001	IRIS	35
Barium	0.05	IRIS	1750
Benzidine	0.003	IRIS	105
Benzoic acid	4	IRIS	140000
Beryllium	0.005	IRIS	175
Gamma BHC (Lindane)	0.0003	IRIS	10.5
Bis(2-ethylhexyl)phthalate	0.02	IRIS	700
Bromodichloromethane	0.02	IRIS	700
Bromoform	0.02	IRIS	700
Bromomethane	0.001	IRIS	35
2-Butanone	0.05	IRIS	1750
Butyl benzyl phthalate	0.2	HEAST	7000
Cadmium	0.0005	HEAST	17.5
Carbon disulfide	0.1	IRIS	3500
Carbon tetrachloride	0.0007	IRIS	24.5
Chlordane	0.00005	IRIS	1.75
4-Chloroaniline	0.004	IRIS	140
Chlorobenzene	0.027	SPHEM	945
Chloroform	0.01	IRIS	350
2-Chlorophenol	0.005	IRIS	175
Chromium III	1	IRIS	35000
Chromium VI	0.005	IRIS	175
Copper	0.037	SPHEM	1295
Cyanide	0.02	b	700
DDT	0.0005	IRIS	17.5
Dibutyl phthalate	0.1	IRIS	3500
1,2-Dichlorobenzene	0.4	HEAST	14000
1,1-Dichloroethane	0.009	IRIS	315
1,1-Dichloroethene	0.009	IRIS	315
2,4-Dichlorophenol	0.003	IRIS	105
Dieldrin	0.00005	IRIS	1.75
Diethyl phthalate	0.8	IRIS	28000
2,4-Dinitrophenol	0.002	IRIS	70
Endosulfan	0.00005	IRIS	1.75
Endrin	0.0003	IRIS	10.5
Ethylbenzene	0.1	IRIS	3500
Heptachlor	0.0005	IRIS	17.5
Heptachlor epoxide	0.000013	IRIS	0.455
Hexachlorobenzene	0.0008	IRIS	28
Hexachlorobutadiene	0.002	IRIS	70
Hexachlorocyclopentadiene	0.007	IRIS	245
Hexachloroethane	0.001	IRIS	35
Isophorone	0.15	IRIS	5250
Lead	0.0014	SPHEM	49
Manganese	0.22	SPHEM	7700
Mercury (alkyl and inorganic)	0.0003	IRIS	10.5
Mercury (inorganic)	0.002	SPHEM	70
Methylene chloride	0.06	IRIS	2100
4-Methyl-2-pentanone	0.05	IRIS	1750
2-Methylphenol	0.5	IRIS	17500
4-Methylphenol	0.5	IRIS	17500
Naphthalene	0.4	HEAST	14000
Nickel	0.02	c	700
Nitrobenzene	0.0005	IRIS	17.5
Pentachlorophenol	0.03	IRIS	1050
Phenol	0.04	IRIS	1400
Pyrene	0.003	HEAST	105
Selenium	0.003	SPHEM	105
Silver	0.003	IRIS	105
Styrene	0.2	IRIS	7000
Tetrachloroethene	0.01	IRIS	350
Thallium	0.00007	HEAST	2.45
Toluene	0.3	IRIS	10500
1,2,4-Trichlorobenzene	0.02	IRIS	700
1,1,1-Trichloroethane	0.09	IRIS	3150
1,1,2-Trichloroethane	0.2	IRIS	7000
2,4,5-Trichlorophenol	0.1	IRIS	3500
Vanadium	0.007	HEAST	245
Xylenes	2	IRIS	70000
Zinc	0.2	HEAST	7000

EXPOSURE ASSUMPTIONS:

Exposure Setting	Residential
Exposed Population	Adults
Water Intake (l/day)	2
Body Weight (kilograms)	70

The "target" concentrations presented in this table do NOT represent a determination of "safe" levels. These target levels are provided for reference purposes only. They can serve as first cut at clean up goals based on human health. The target levels provided are for individual chemicals and only one route of exposure.

a. Sources of RfDs:
IRIS - Integrated Risk Information System. U.S. EPA 1988.
SPHEM - Superfund Public Health Evaluation Manual. U.S.EPA 1986
HEAST - Health Effects Assessment Summary Tables - Quarterly Summary. U.S. EPA 1989

b. Cyanide value based on free cyanide.

c. Nickel value base on nickel-soluble salts.

Table 6

RISK-BASED TARGET DRINKING WATER CONCENTRATIONS FOR INDIVIDUAL CHEMICALS
BASED ON CARCINOGENIC EFFECTS
BASED ON INGESTION

Chemical	U.S EPA Carcinogen Classification	Carcinogenic Potency Factor (kg-day/mg)	Source a	Target Cancer Risk: 1E-04 ug/l	Target Cancer Risk: 1E-05 ug/l	Target Cancer Risk: 1E-06 ug/l
Aldrin	B2	17	IRIS	2.1E-01	2.1E-02	2.1E-03
Aroclor 1016	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
Aroclor 1221	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
Aroclor 1232	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
Aroclor 1242	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
Aroclor 1248	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
Aroclor 1254	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
Aroclor 1260	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
Arsenic	A	1.75	HEAST	2.0E+00	2.0E-01	2.0E-02
Benzene	A	0.029	IRIS	1.2E-02	1.2E-01	1.2E-00
Benzic ne	A	230	IRIS	1.5E-02	1.5E-03	1.5E-04
Benzo[a, nthracene	B2	11.5	b	3.0E-01	3.0E-02	3.0E-03
Benzo[b]fluoranthene	B2	11.5	b	3.0E-01	3.0E-02	3.0E-03
Benzo[k]fluoranthene	B2	11.5	b	3.0E-01	3.0E-02	3.0E-03
Benzo[a]pyrene	B2	11.5	SPHEM	3.0E-01	3.0E-02	3.0E-03
Benzo[g,h,i]perlyene	B2	11.5	b	3.0E-01	3.0E-02	3.0E-03
alpha BHC	B2	6.3	IRIS	5.6E-01	5.6E-02	5.6E-03
Beta BHC	C	1.8	IRIS	1.9E+00	1.9E-01	1.9E-02
gamma BHC (Lindane)	B2	1.3	HEAST	2.7E-00	2.7E-01	2.7E-02
Bis(2-chloroethyl)ether	B2	1.1	IRIS	3.2E+00	3.2E-01	3.2E-02
Bis(chloromethyl)ether	A	220	IRIS	1.6E-02	1.6E-03	1.6E-04
Bis(2-ethylhexyl)phthalate	B2	0.014	IRIS	2.5E+02	2.5E+01	2.5E+00
Bromodichloromethane	B2	0.13	HEAST	2.7E+01	2.7E+00	2.7E-01
Carbon tetrachloride	B2	0.13	IRIS	2.7E+01	2.7E+00	2.7E-01
Chlordane	B2	1.3	IRIS	2.7E+00	2.7E-01	2.7E-02
4-Chloroaniline	C	0.035	HEAST	1.0E+02	1.0E+01	1.0E+00
Chloroform	B2	0.0061	IRIS	5.7E+02	5.7E+01	5.7E+00
Chloromethane	C	0.013	HEAST	2.7E+02	2.7E+01	2.7E+00
Chyrsene	C	11.5	b	3.0E+01	3.0E+02	3.0E-03
DDD	B2	0.24	IRIS	1.5E+01	1.5E+00	1.5E-01
DDE	B2	0.34	IRIS	1.0E+01	1.0E+00	1.0E-01
DDT	B2	0.34	IRIS	1.0E+01	1.0E+00	1.0E-01
Dibenz[a,h]anthracene	B2	11.5	b	3.0E-01	3.0E-02	3.0E-03
1,4-Dichlorobenzene	B2	0.024	HEAST	1.5E+02	1.5E+01	1.5E+00
3,3'-Dichlorobenzidene	B2	0.45	HEAST(V)	7.8E-00	7.8E-01	7.8E-02
1,1-Dichloroethane	C	0.091	HEAST	3.8E+01	3.8E+00	3.8E-01
1,2-Dichloroethane	B2	0.091	IRIS	3.8E+01	3.8E+00	3.8E-01
1,1-Dichloroethene	C	0.6	IRIS	5.8E+00	5.8E-01	5.8E-02
1,2-Dichloropropane	B2	0.068	HEAST	5.1E+01	5.1E+00	5.1E-01
Dieldrin	B2	16	IRIS	2.2E-01	2.2E-02	2.2E-03
2,4-Dinitrotoluene	B2	0.68	HEAST(V)	5.1E+00	5.1E-01	5.1E-02
Heptachlor	B2	4.5	IRIS	7.8E-01	7.8E-02	7.8E-03
Heptachlor epoxide	B2	9.1	IRIS	3.8E+01	3.8E-02	3.8E-03
Hexachlorobenzene	B2	1.7	HEAST	2.1E+00	2.1E-01	2.1E-02
Hexachlorobutadiene	C	0.078	IRIS	4.5E+01	4.5E+00	4.5E-01
Hexachloroethane	C	0.014	IRIS	2.5E+02	2.5E+01	2.5E+00
Indeno[1,2,3-cd]pyrene	B2	11.5	b	3.0E-01	3.0E-02	3.0E-03
Isophorone	C	0.0041	HEAST	8.5E+02	8.5E+01	8.5E+00
Methylene chloride	B2	0.0075	IRIS	4.7E+02	4.7E+01	4.7E+00
N-Nitroso-di-n-propylamine	B2	7	IRIS	5.0E-01	5.0E-02	5.0E-03
Nitrosodiphenylamine	B2	0.0049	IRIS	7.1E+02	7.1E+01	7.1E+00
PCB	B2	7.7	HEAST(V)	4.5E-01	4.5E-02	4.5E-03
PAHS	B2/C	11.5	SPHEM	3.0E-01	3.0E-02	3.0E-03
2,3,7,8-TCDD (Dioxin)	B2	156000	SPHEM	2.2E-05	2.2E-06	2.2E-07
1,1,2,2 Tetrachloroethane	C	0.2	IRIS	1.8E+01	1.8E+00	1.8E-01
Tetrachloroethene	B2	0.051	SPHEM	6.9E+01	6.9E+00	6.9E-01
Toxaphene	B2	1.1	IRIS	3.2E+00	3.2E-01	3.2E-02
1,1,2-Trichloroethane	C	0.057	IRIS	6.1E+01	6.1E+00	6.1E-01
Trichloroethene	B2	0.011	IRIS	3.2E+02	3.2E+01	3.2E+00
2,4,6-Trichlorophenol	B2	0.02	IRIS	1.8E+02	1.8E+01	1.8E+00
Vinyl chloride	A	2.3	SPHEM	1.5E+00	1.5E-01	1.5E-02

EXPOSURE ASSUMPTIONS:

Exposure Setting:	Residential
Daily water intake (l/day)	2
Body weight (kilograms)	70
Number of days/week exposed	7
Number of weeks/year expose	52
Number of years exposed	70
Lifetime average water inta (liter/kg body weight/day)	0.029

The "target" concentrations presented in this table do NOT represent a determination of "safe" levels. These target levels are provided for reference purposes only. They can serve as first cut at clean up goals based on human health. The target levels provided are for individual chemicals and only one route of exposure.

a. Sources of Cancer Potency Factors:
IRIS - Integrated Risk Information System. U.S. EPA 1988.
SPHEM - Superfund Public Health Evaluation Manual. U.S.EPA 1986
HEAST - Health Effects Assessment Summary Tables - Quarterly Summary. U.S. EPA 1989
HEAST(V) - Health Effects Assessment Summary Tables - Quarterly Summary. U.S. EPA 1989. verified values awaiting entry into IRIS.
b. Based on Benzo[a]pyrene.

STATE OF MICHIGAN

JAMES J. BLANCHARD, Governor

DEPARTMENT OF NATURAL RESOURCES

STEVENS T MASON BUILDING
P.O. BOX 30028
LANSING, MI 48909

DAVID F. HALES, Director

January 24, 1989

TO: All Interested Parties

FROM: Paul D. Zugger, Chief
Surface Water Quality Division

SUBJECT: Rule 57(2) Guideline Levels

The Rule 57(2) Guidelines state that the most recent calculations of water quality-based levels of toxic substances developed pursuant to the Guidelines shall be compiled on an annual basis and be available for distribution by February 1 of each year. The following list is in fulfillment of that requirement, and is complete as of January 23, 1988. The values are subject to change as new data or information becomes available.

Rule 57(2) Guideline Levels are utilized in making water quality-based permit recommendations to the Water Resources Commission concerning toxic substances in the surface water after a point source discharge is mixed with the receiving stream volume specified in R323.1082. These levels do not represent acceptable ambient levels in all waters of the state, nor do they represent or reflect necessary treatment-based considerations.

This list is informational only and is not a mechanism to establish water quality-based permit limits. It is advisory in nature and not meant to be binding on anyone.

Water quality-based permit limitations for toxic chemicals are developed by staff in the Great Lakes and Environmental Assessment Section using the R323.1057(2) Guidelines and appropriate scientific data.

Questions concerning this list should be directed to Linn Duling, of the Great Lakes and Environmental Assessment Section at 517/335-4188.

Revised January 23, 1989

CHEMICAL NAME	CAS NUMBE	Rule 57(2) Level Non-Drink Water Value (ug/l)	Basis
Arsenic	Class 011	184	ACV
Cadmium (coldwater)	Class 013	@exp(0.83(@ln(H))-4.84)	ACV
Chromium	Class 015	@exp(0.83(@ln(H))+0.131)	ACV
Copper (coldwater)	Class 017	@exp(0.94(@ln(H))-1.3)	ACV
Cyanide (coldwater)	Class 018	4	ACV
Lead	Class 019	@exp(1.75(@ln(H))-7.00)	ACV
Nickel	Class 022	@exp(0.92(@ln(H))+0.12)	ACV
Zinc	Class 027	@exp(0.85(@ln(H))+0.67)	ACV
Molybdenum	Class 031	180	ACV
Paraquat	Class 067	16	ACV
PCB #	Class 079	0.00002	CRV
DDT #	50293	0.00013	CRV
Phenol, 2,4-dinitro	51285	9.8	ACV
Carbon tetrachloride #	56235	27	CRV
Chlordane #	57749	0.00053	CRV
Lindane #	58899	0.097	CRV
Phenol, 4-chloro-3-methyl	59507	4.4	ACV
Dieldrin #	60571	0.0000315	CRV
Aniline #	62533	4	ACV
Acetone	67641	500	TLSC
Chloroform #	67663	43	CRV
Hexachloroethane #	67721	13	CRV
Benzene #	71432	60	TLSC
Ethane, 1,1,1-trichloro	71556	117	ACV
Methylene chloride #	75092	59	ACV
Ethylene oxide #	75218	56	CRV
Bromoform	75252	65	ACV
Ethylene, 1,1-dichloro #	75354	2.6	CRV
Hexachlorocyclopentadiene	77474	0.5	ACV
Isophorone	78591	860	ACV
Propane, 1,2-dichloro	78875	283	ACV
Ethane, 1,1,2-trichloro #	79005	65	CRV
Trichloroethylene #	79016	94	ACV
Pentachlorophenol <= pH 8.1	87865	@exp(1.0051*pH-5.0336)	ACV
Pentachloropehnol >pH 8.1	87865	23	HLSC
Dinoseb	88857	@exp(1.5837*pH-12.8931)	ACV
Naphthalene	91203	29	ACV
Benzidine, 3,3-dichloro #	91941	0.06	CRV
Benzidine #	92875	0.0399	CRV*
Silvex	93721	21.3	HLBC
Acetic acid, 2,4-dichlorophenoxy-	94757	46.7	ACV
Benzene, 1,2-dichloro	95501	7	ACV
Phenol, 2-chloro	95578	10	ACV
Ethylbenzene	100414	30	ACV
Styrene #	100425	19	CRV
Benzene, 1,4-dichloro #	106467	15	CRV
Phenol, 4-chloro	106489	9.3	ACV
Ethylene dibromide #	106934	1.1	CRV*
Acrolein	107028	3	ACV

Revised January 23, 1989

CHEMICAL NAME	CAS NUMBE	Rule 57(2) Level Non-Drink Water Value (ug/l)	Basis
Ethane, 1,2-dichloro #	107062	560	CRV
Acrylonitrile #	107131	2.2	CRV$
Toluene	108883	100	ACV
Chlorobenzene	108907	71	ACV
Phenol	108952	135	HLSC
Bis(2-chloroethyl)ether #	111444	4.2	CRV
Bis(2-chloroethoxy) methane	111911	4.6	TLSC
Benzene, 1,2,4-trichloro	120821	22	HLSC
Phenol, 2,4-dichloro	120832	@exp(0.3589$pH+0.7595)	ACV
1,4-dioxane #	123911	360	ACV
Tetrachloroethylene #	127184	16	CRV
Ethylene, t-1,2-dichloro	156605	300	ACV
Benzene, 1,3-dichloro	541731	179	ACV
Xylene	1330207	59	ACV
Tetra n-butyl ammonium bromide	1643192	140	TLSC
2,3,7,8-TCDD #	1746016	0.000000014	CRV$
Di-N-propyl formamide	6282004	63	TLSC
Mercury, methyl	7439976	0.0006	HLSC
Ammonia, unionized (Warmwater)	7664417	50	ACV
Ammonia, unionized (Coldwater)	7664417	20	ACV
Chlorine	7782505	6	ACV
DBNPA	10222012	4	ACV
Chromium, hexavalent	18540299	6	ACV

NOTES:

- This chemical is regulated as a carcinogen. The Rule 57(2) Level is not necessarily based on its 1 in 100,000 cancer risk value.
$ - Professional judgement was used - minimum data not available.

ACV = Aquatic Chronic Value
TLSC = Terrestrial Life-cycle Safe Concentration
HLSC = Human Life-cycle Safe Concentration
CRV = Cancer Risk Value
CAS = Chemical Abstract Service Number

H = Hardness 266 mg/L (Page 81)

Exponential equations: e.g., $@exp(0.83(@ln(H))-4.84) = e^{0.83(\ln H)-4.8}$

where H = Hardness (mg/l as CaCO3)

$@exp(1.0051$pH-5.1878) = e^{1.0051(pH)-5.}$

where pH is in Standard Units

Appendix B
ACTION LEVELS FOR COMPOUNDS DETECTED IN GROUNDWATER DURING THE RI AND LAGOON RD

Appendix B

ACTION LEVELS FOR COMPOUNDS DETECTED IN GROUNDWATER DURING THE RI AND LAGOON RD

CONSTITUENTS	CLP CONTRACT REQUIRED DETECTION LIMITS (ug/l)	DRINKING WATER ACTION LEVELS (ug/l)	WETLAND PROTECTION ACTION LEVELS (ug/l)
VOLATILE ORGANIC COMPOUNDS			
Chloroethane	10	----	----
Methylene Chloride	5	4.7 (3)	59 (5)
Acetone	10	3500 (4)	500 (5)
1,1-Dichloroethene	5	7 (1)	2.6 (5)
1,1-Dichloroethane	5	4200 (4)	----
Trans-1,2-Dichloroethene	5	70 (2)	300 (5)
1,2-Dichloroethene (total)	5	70 (2)	300 (5)
1,2-Dichloroethane	5	5 (1)	560 (5)
2-Butanone	10	1750 (4)	----
1,1,1-Trichloroethane	5	200 (1)	117 (5)
1,2-Dichloropropane	5	5 (2)	283 (5)
Trichloroethene	5	5 (1)	94 (5)
1,1,2-Trichloroethane	5	0.6 (3)	----
Benzene	5	5 (1)	60 (5)
2-Hexanone	10	----	----
4-Methyl-2-pentanone	10	1750 (4)	----
Tetrachloroethene	5	0.7 (3)	16 (5)
Toluene	5	2000 (2)	100 (5)
SEMI-VOLATILE ORGANIC COMPOUNDS			
Phenol	10	1400 (4)	135 (5)
2-Methylphenol	10	1750 (4)	----
4-Methylphenol	10	1750 (4)	----
Benzoic Acid	50	140000 (4)	----
Bis(2-ethylhexyl)phthalate	10	25 (3)	----
Di-n-octyl Phthalate	10	----	----
INORGANIC CONSTITUENTS			
Arsenic	10	50 (1)	184 (5)
Barium	200	1000 (1)	----
Chromium (total)	10	50 (1)	117 (5)
Lead	5	50 * (1)	16 (5)
Nickel	40	700 (4)	192 (5)
Zinc	20	5000 (1)	225 (5)
Cyanide	10	700 (4)	4 (5)

---- No standard, guideline, or criteria is currently available for this compound

* Proposed MCL for lead is 5 ug/l

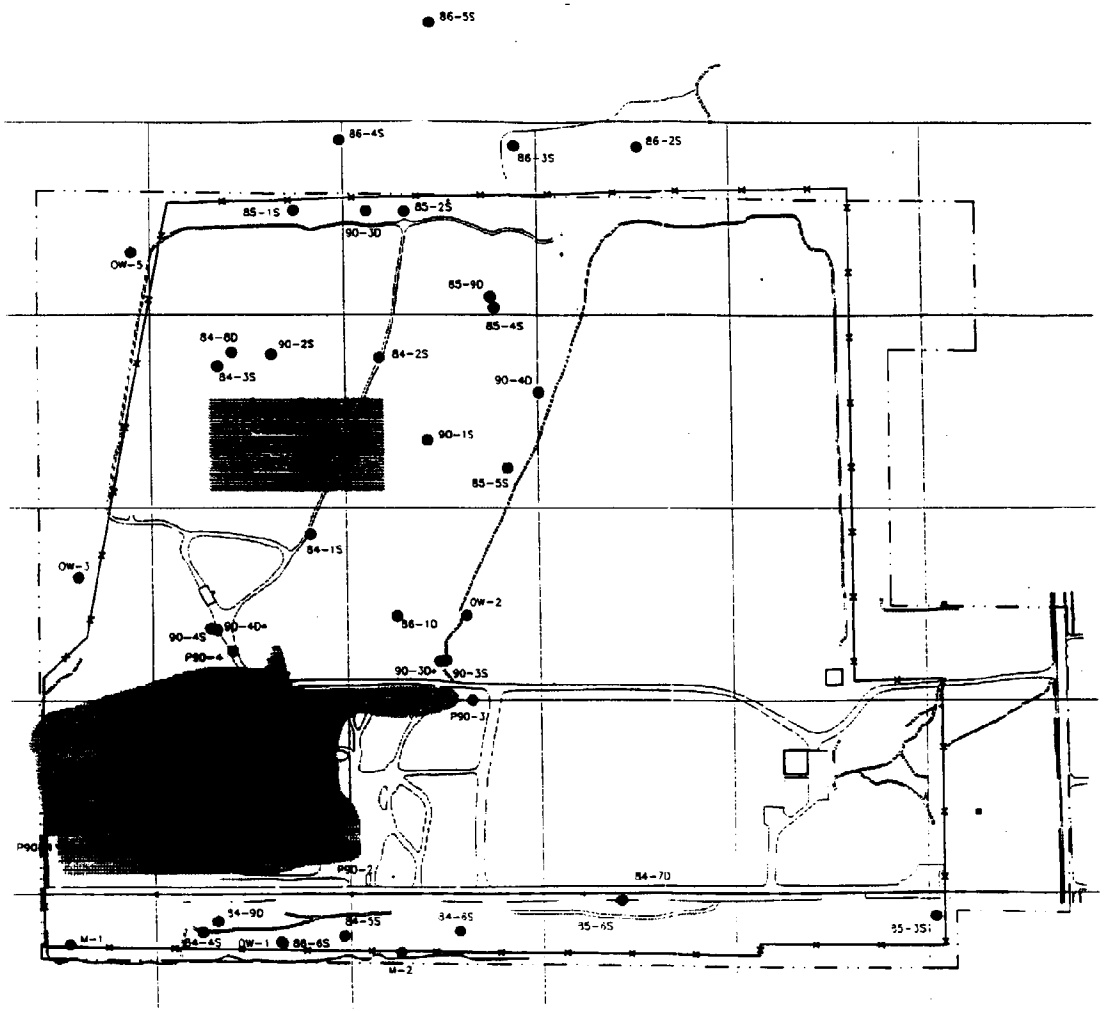
(1) MCL

(2) MCLG

(3) Risk-Based Target Concentrations - Carcinogens

(4) Risk-Based Target Concentrations - Noncarcinogens

(5) Michigan Surface Water Criteria



LEGEND

- PROPERTY LINE
- FENCE
- 84-2S ● MONITORING WELL LOCATION (MONITORING WELL NUMBER)
- 85-3S ● MONITORING WELL LOCATION (MONITORING WELL NUMBER (NOT INCLUDED IN SAMPLING))

SCALE

0 150 300 600 FEET

MONITORING WELL LOCATION PLAN
OTISVILLE, MICHIGAN

PREPARED FOR
FOREST WASTE
COORDINATING COMMITTEE

McLaren Hart
ENVIRONMENTAL ENGINEERING CORPORATION

DATE: 08/30/98 | FIGURE 2 | DRAWING NUMBER 1053B004
SCALE: AS SHOWN

REFERENCE:
DONOHUE FINAL PRE-DESIGN INVESTIGATION REPORT
U.S. ARMY CORPS OF ENGRS. CONT #DACW-45-90-C-0030
APR. 1991 DONOHUE JOB #17617

NOTE:
1. FEATURES GATHERED BY AERIAL PHOTOGRAMMETRY METHODS FROM DECEMBER 12, 1993 PHOTO.

REVISIONS: NO. | DESCR | APPR | BY

DRAWN BY: BJF | DATE: 08/01/95
CHECKED BY | APPROVED BY

DRAWING NUMBER: 1053B0C

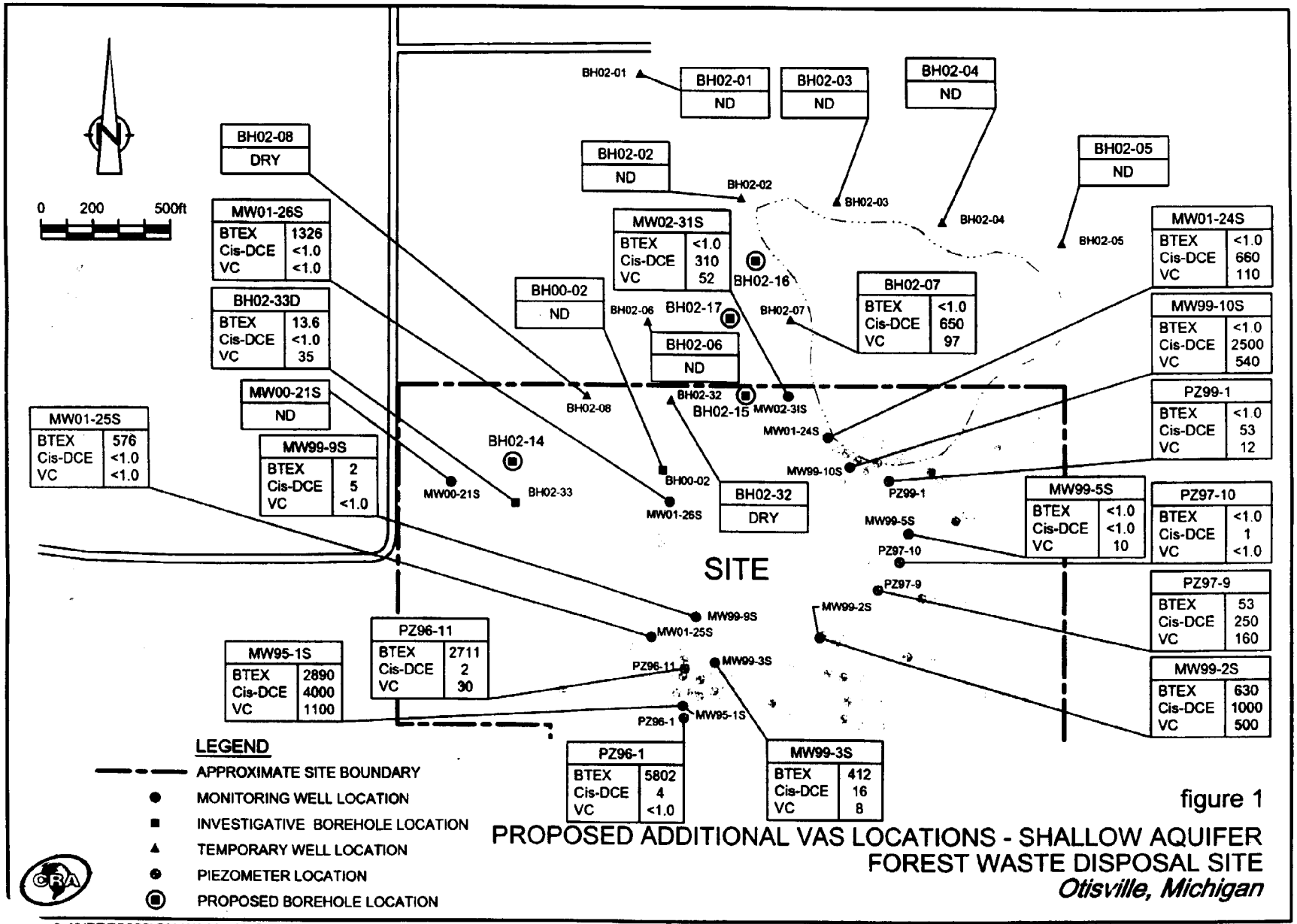
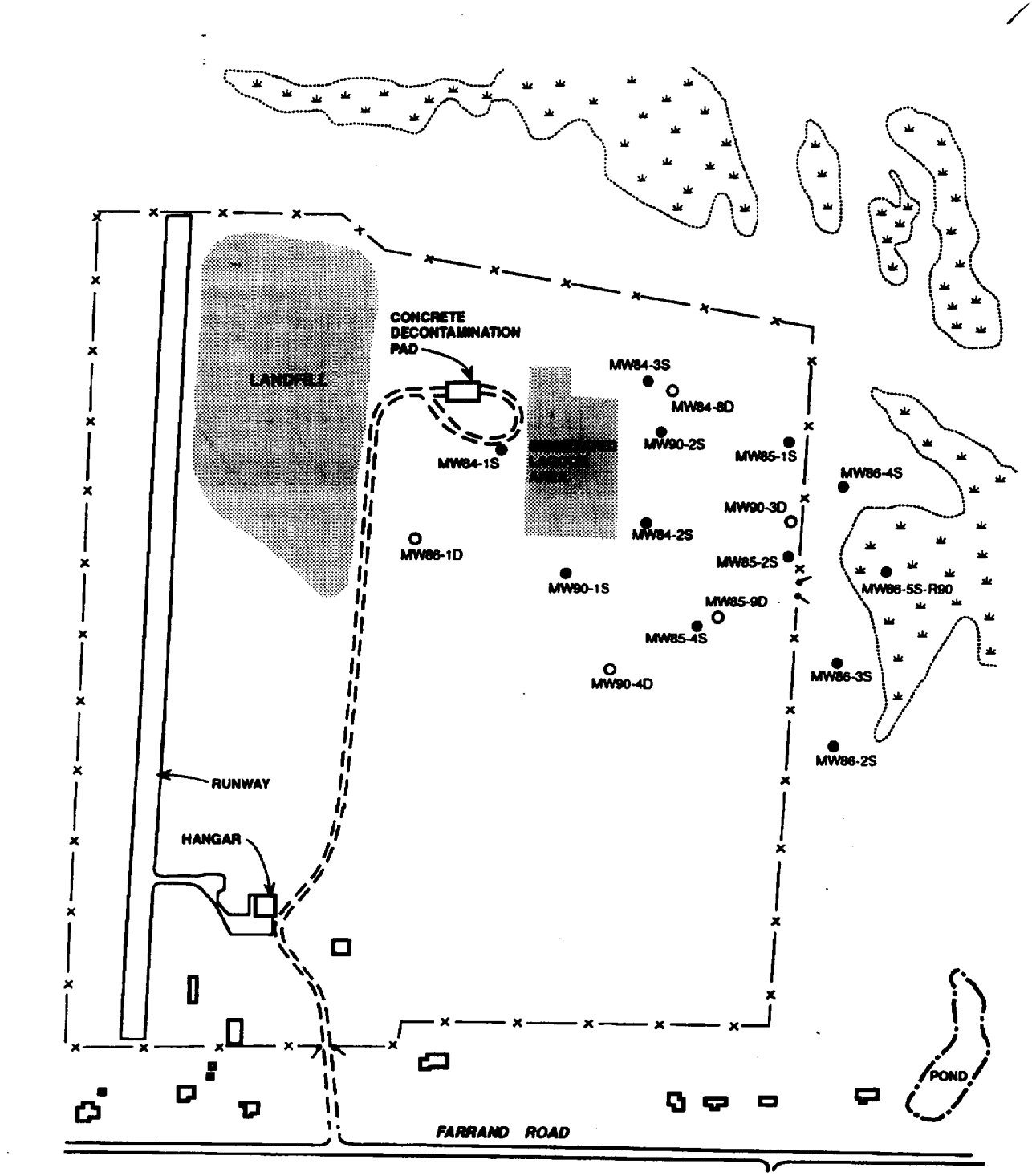


figure 1

PROPOSED ADDITIONAL VAS LOCATIONS - SHALLOW AQUIFER
FOREST WASTE DISPOSAL SITE
Otisville, Michigan

9-40(PRES005)GN-WA001 AUG 27/2002



LEGEND

- SITE FENCE
- GATE
- HOUSE OR STRUCTURE
- GRAVEL ACCESS ROAD
- WETLANDS
- SHALLOW MONITORING WELL
- DEEP MONITORING WELL

N

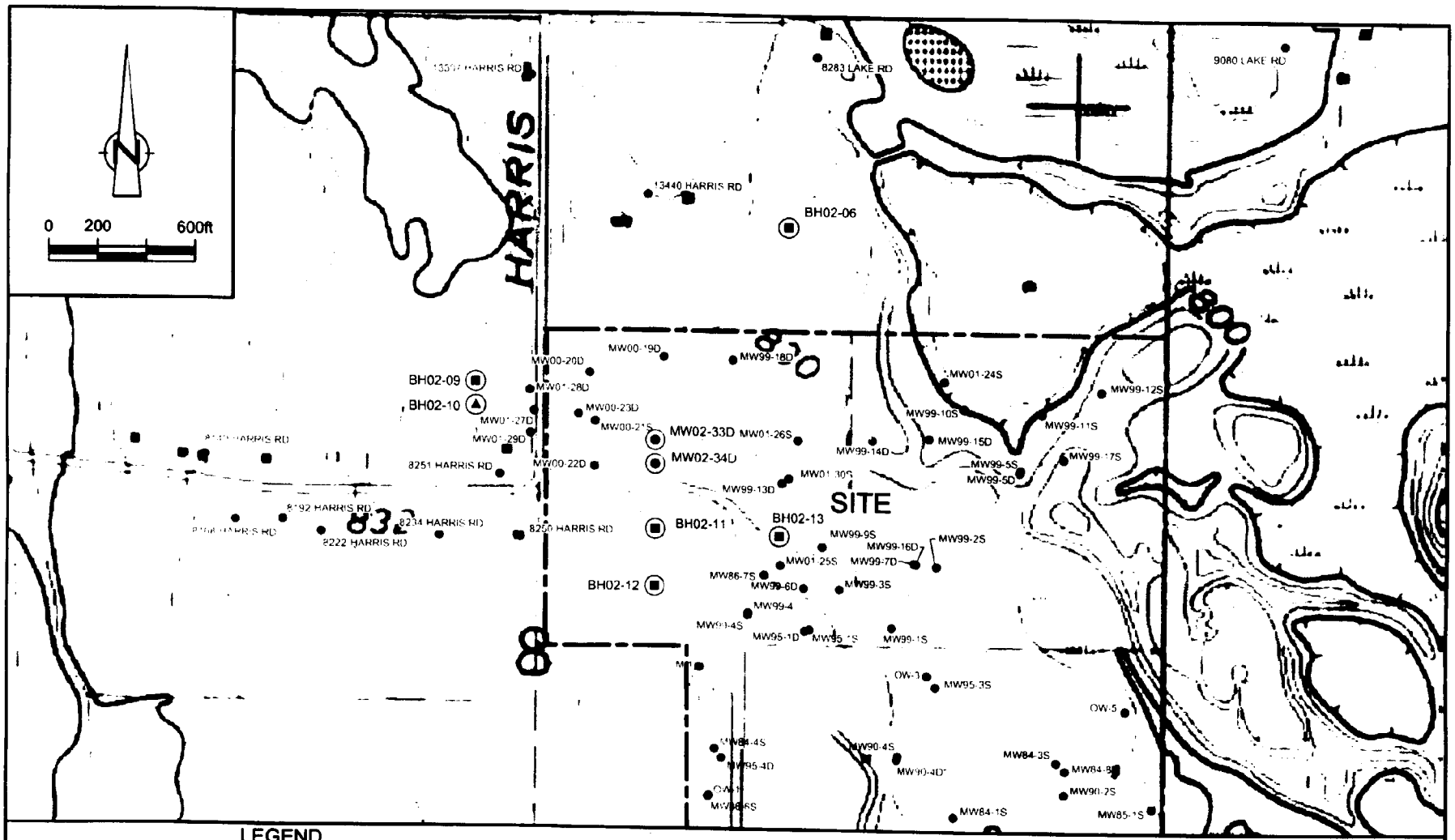
0 400

SCALE IN FEET

NOTE: LOCATIONS ARE APPROXIMATE.

GLO65572.CM MON WELL NTWRK 7-26-91mms

FIGURE 1
MONITORING WELL NETWORK
Forest Waste Remedial Action
Annual Report



LEGEND

- RESIDENTIAL WELL (APPROXIMATE LOCATION)
- APPROXIMATE SITE BOUNDARY
- PROPOSED PERMANENT MONITORING WELL LOCATION
- PROPOSED INVESTIGATIVE BOREHOLE LOCATION
- PROPOSED TEMPORARY WELL LOCATION

BACKGROUND SOURCE: USGS QUADRANGLE MAP; OTISVILLE, MICHIGAN

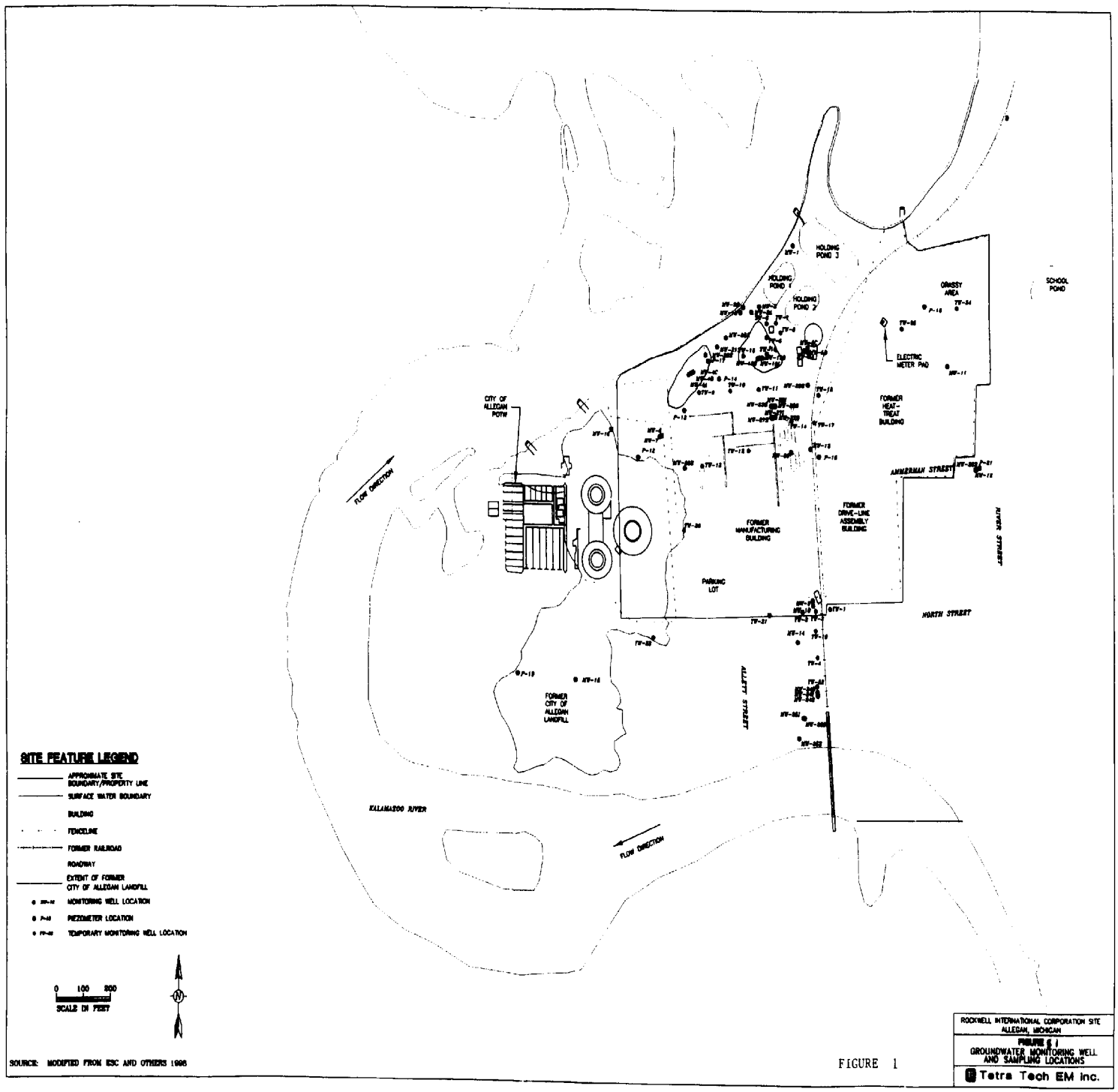
NOTE: ALL WELLS AND BOREHOLE ARE APPROXIMATE POSITIONS ONLY; PLOTTED OFF MUNICIPAL WELL LOGS

figure 2

PROPOSED SCOPE OF WORK DEEP AQUIFER FOREST WASTE DISPOSAL SITE

Otisville, Michigan

12210-40(009)GN-WA002 JUN 21/2002



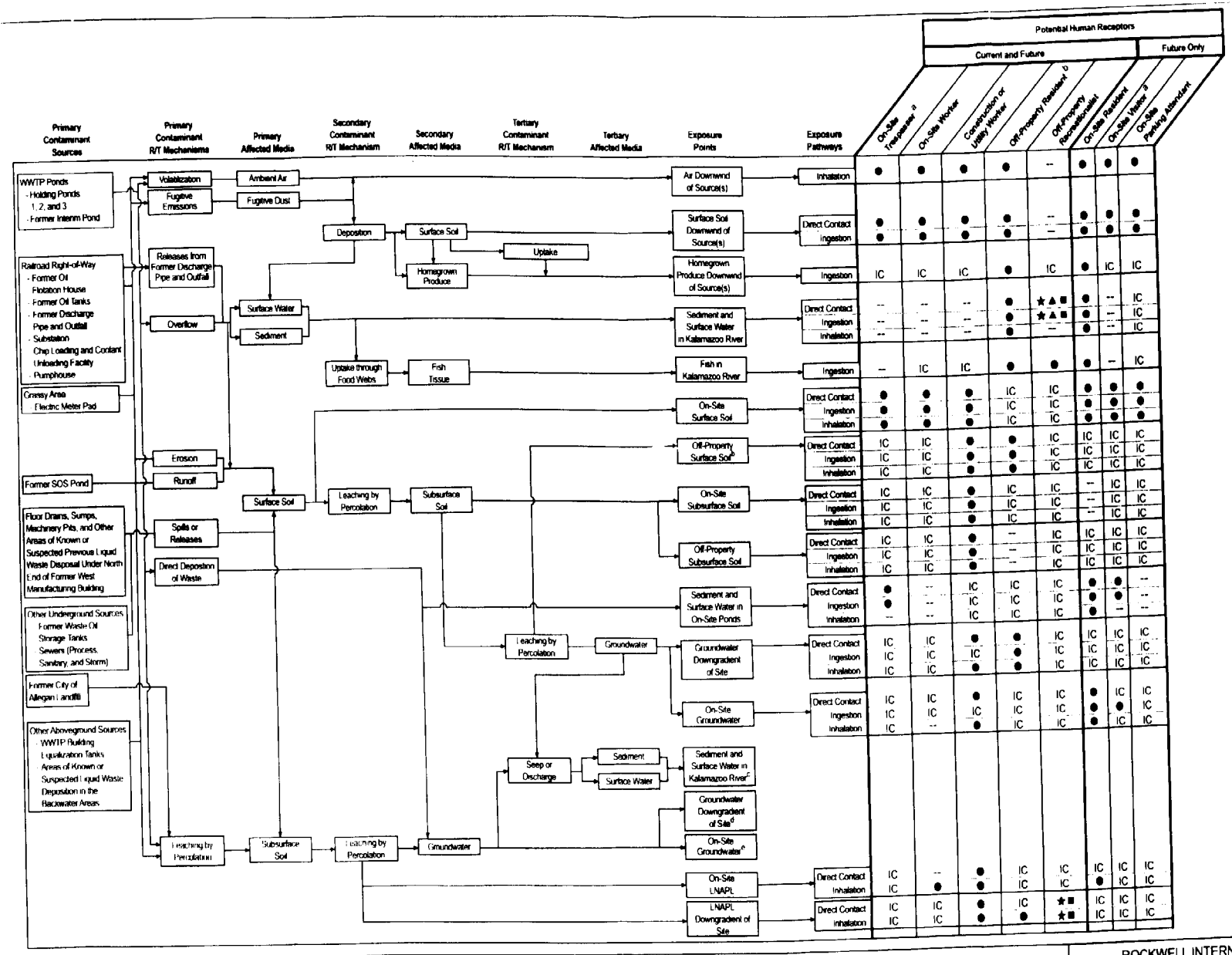
SOURCE: MODIFIED FROM ESC AND OTHERS 1998

FIGURE 1

ROCKWELL INTERNATIONAL CORPORATION SITE
ALLEGAN, MICHIGAN

FIGURE 6-1
GROUNDWATER MONITORING WELL AND SAMPLING LOCATIONS

Tetra Tech EM Inc.



Notes:

R/T = Release or transport

▲,■,● = Potentially complete exposure pathway retained for quantitative analysis

★ = Swimming

▲ = Fishing

■ = Walking or wading along river's edge

IC = Incomplete exposure pathway

-- = *De Minimis* exposure pathway

[a] = The current on-site trespasser exposure scenario includes children and teenagers who may occasionally trespass on the site. The future on-site visitor exposure scenario includes children and adults who may visit a future park.

[b] = Site-related contaminants have migrated through subsurface soil and groundwater to a low-lying area in an off-property resident's backyard.

[c] = The exposure routes and scenarios are the same as those listed above under the "Sediment and Surface Water in Kalamazoo River" exposure points.

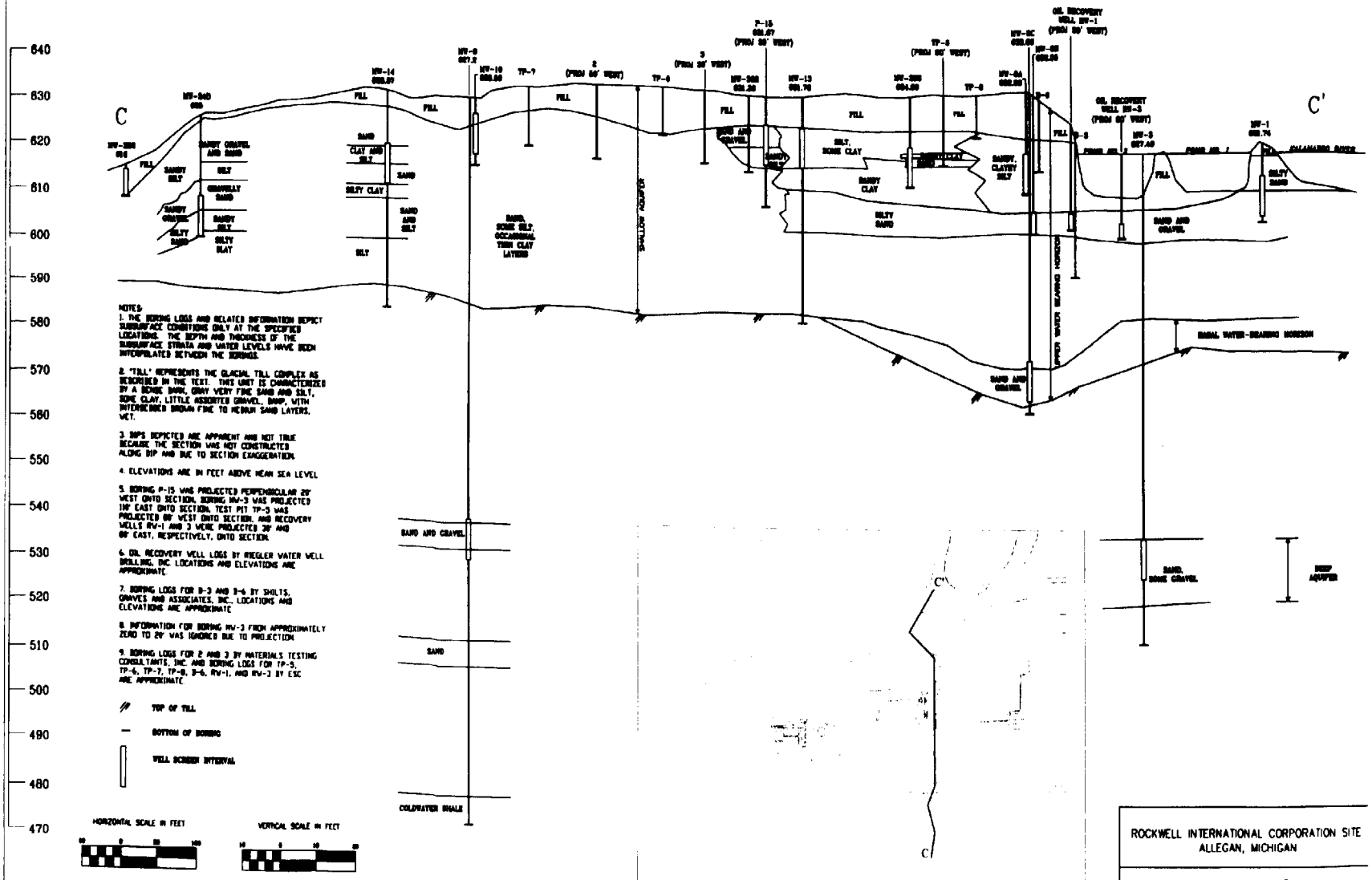
[d] = The exposure routes and scenarios are the same as those listed above under the "Groundwater Downgradient of Site" exposure points.

[e] = The exposure routes and scenarios are the same as those listed above under the "On-site Groundwater" exposure points.

ROCKWELL INTERNATIONAL CORPORATION SITE
ALLEGAN, MICHIGAN

FIGURE 2
CONCEPTUAL SITE MODEL

Tetra Tech EM Inc



SOURCE: MODIFIED FROM ENVIRONMENTAL STRATEGIES CORPORATION 1998

ROCKWELL INTERNATIONAL CORPORATION SITE
ALLEGAN, MICHIGAN

FIGURE 3
GEOLOGIC CROSS SECTION C-C'

Tetra Tech EM Inc.

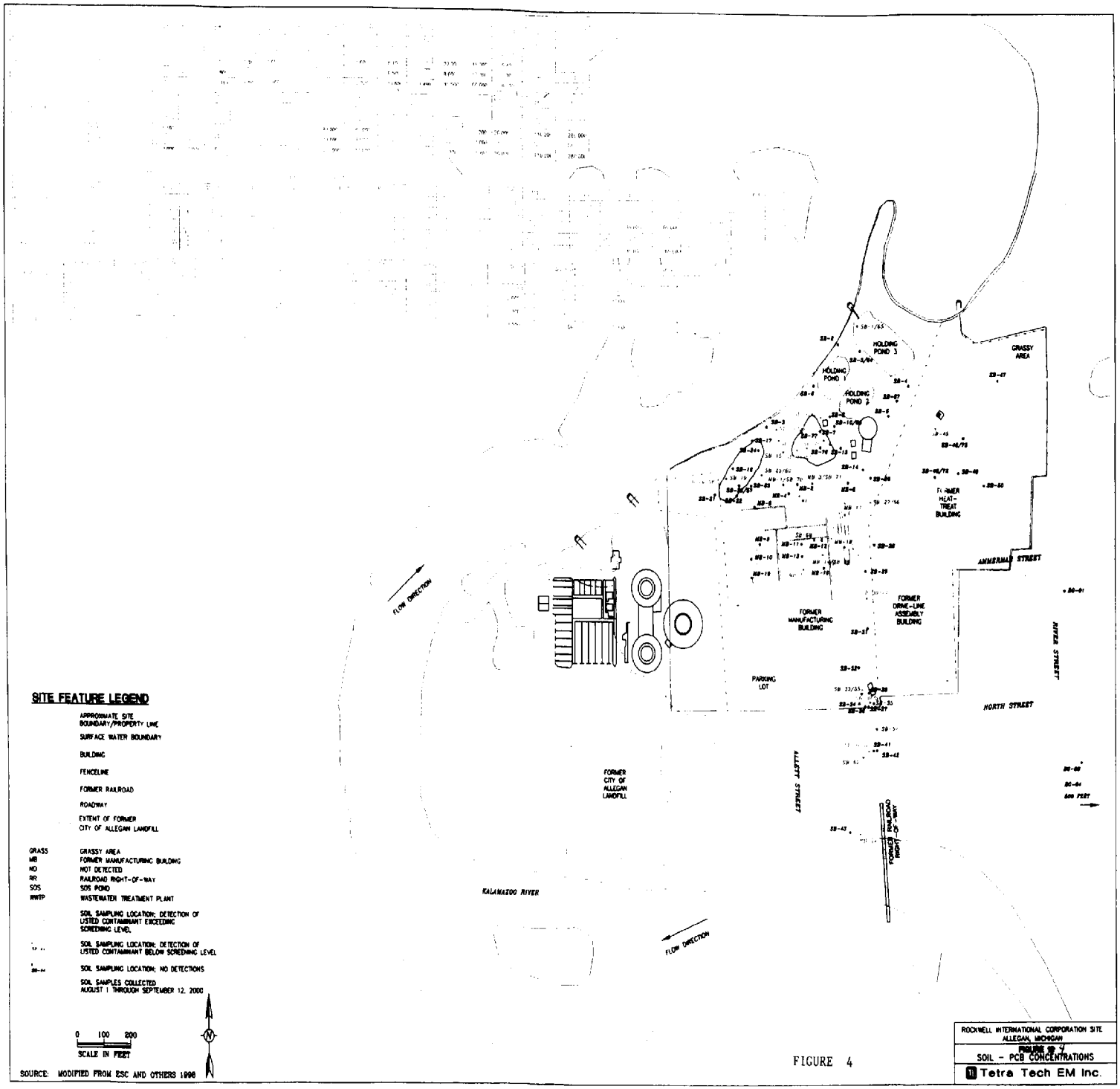


FIGURE 4

ROCKWELL INTERNATIONAL CORPORATION SITE
ALLEGAN, MICHIGAN
FIGURE NO. 4
SOIL - PCB CONCENTRATIONS
Tetra Tech EM Inc.

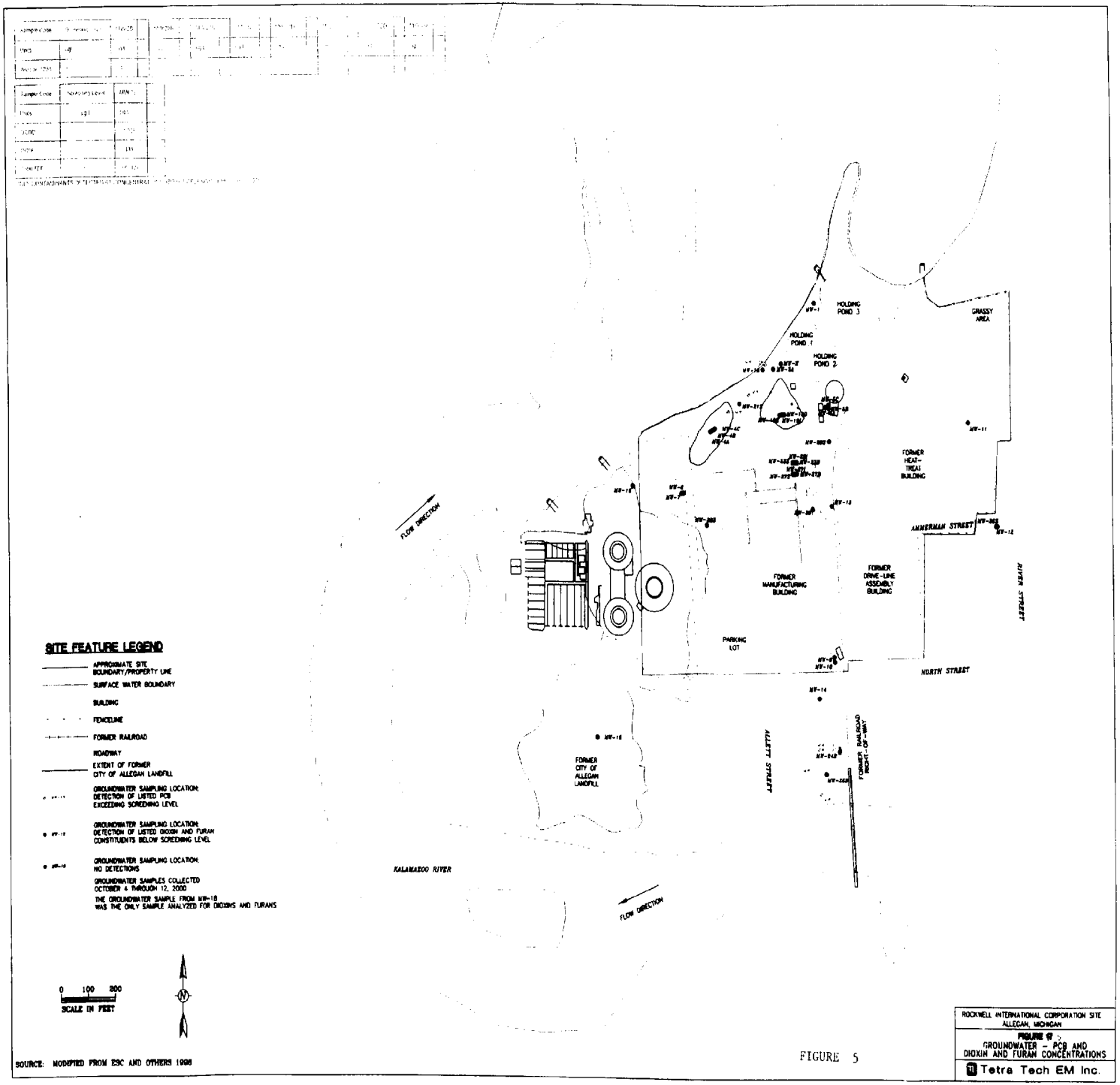
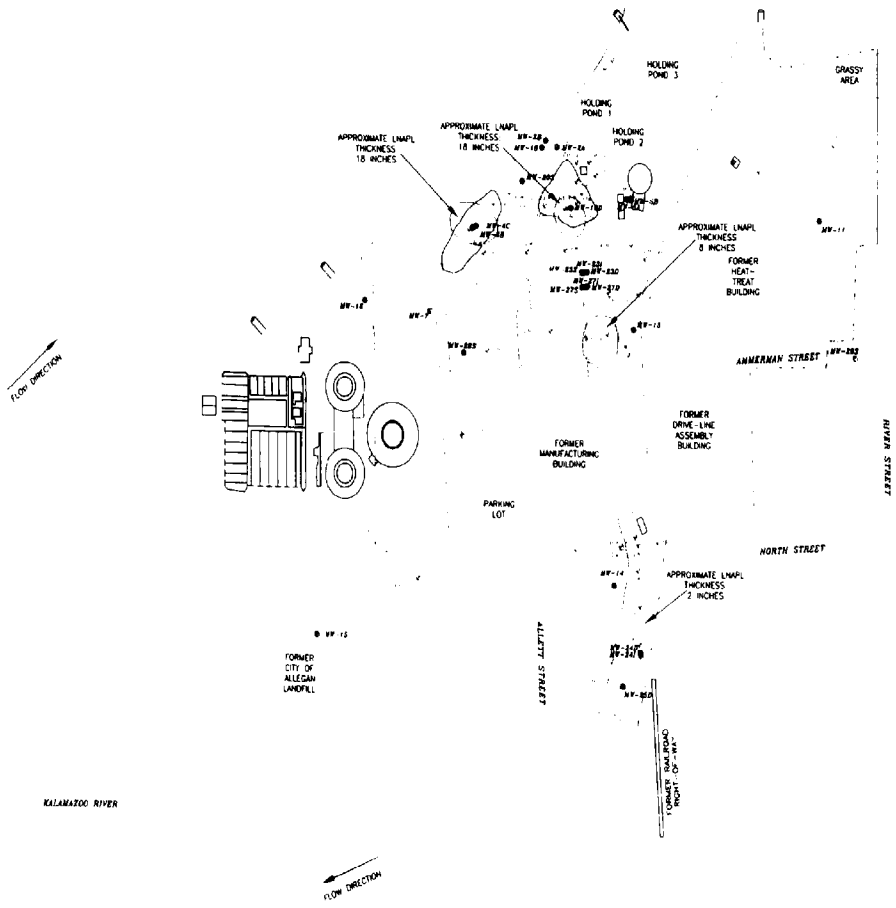


FIGURE 5

ROCKWELL INTERNATIONAL CORPORATION SITE
ALLEGAN, MICHIGAN

FIGURE 5 :
GROUNDWATER – PCB AND DIOXIN AND FURAN CONCENTRATIONS

Tetra Tech EM Inc.



SITE FEATURE LEGEND

- APPROXIMATE SITE BOUNDARY/PROPERTY LINE
- SURFACE WATER BOUNDARY
- BUILDING
- FENCELINE
- FORMER RAILROAD
- ROADWAY
- EXTENT OF FORMER CITY OF ALLEGAN LANDFILL
- ESTIMATED EXTENT LNAPL/SHEEN (APPROXIMATE LNAPL THICKNESS 1 INCH)
- ISOLATED AREAS OF LNAPL GREATER THAN 1 INCH THICK; APPROXIMATE LNAPL THICKNESS IS NOTED
- MONITORING WELL LOCATION LNAPL/SHEEN OBSERVED
- MW-12 MONITORING WELL LOCATION LNAPL/SHEEN NOT OBSERVED
- TEMPORARY MONITORING WELL LOCATION LNAPL/SHEEN OBSERVED
- TEMPORARY MONITORING WELL LOCATION LNAPL/SHEEN NOT OBSERVED
- MONITORING WELL LOCATION, SCREENED IN THE FILL LAYER

0 100 200
SCALE IN FEET

SOURCE MODIFIED FROM ESC AND OTHERS 1998

FIGURE 6

ROCKWELL INTERNATIONAL CORPORATION SITE
ALLEGAN, MICHIGAN
FIGURE 6
EXTENT OF LNAPL/SHEEN OBSERVED
Tet a Tech EM Inc.